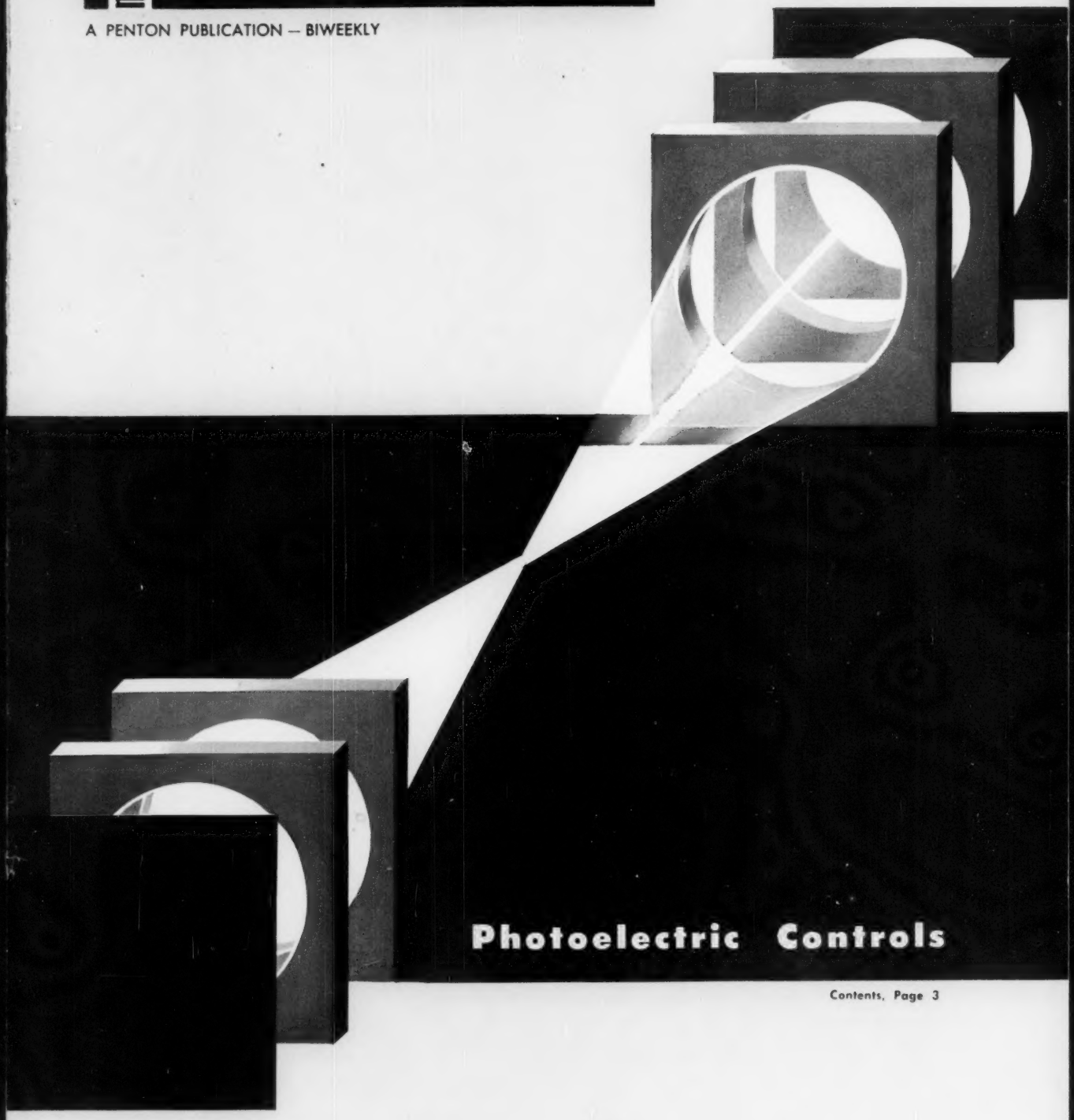
NOVEMBER 27, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Photoelectric Controls

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America's Most Complete Line of Self-Protected Bearings

"Cartridge" 4-way Flinger Sealed Bearing
"Cartridge" Labyrinth Sealed Bearing (Removable Seals)
Felt Sealed Bearing (Removable Seals)
Metal Shielded Bearing
"Plastiseal" Rubber Sealed Bearing

NORMA-HOFFMANN

Sealed Bearings

Give You Dependable Trouble-Free Performance

There's a good reason why Norma-Hoffmann Sealed Bearings give such outstanding performance under all types of operating conditions.

First — the efficient seals, metal, synthetic rubber, or felt, keep grease in . . . keep dirt, dust and other harmful material out. The special seal designs eliminate race distortion, assure dimensional exactness and quiet operation. They simplify mountings . . . speed up assembly.

Second — all Norma-Hoffmann sealed bearings are "factory packed" with a carefully metered quantity of high quality filtered grease . . . grease that is highly resistant to oxidation . . . grease chosen to meet specific operating temperature requirements.

Result — trouble-free performance over long periods without regreasing.

Investigate Norma-Hoffmann sealed and other bearings for your equipment. Write for engineering assistance and catalog.

Circle 401 on Page 19

Special Seal Design PLUS the right grease for the application insures against dry bearings.

precision ball, roller & thrust bearings

NORMA-HOFFMANN

BEARINGS CORPORATION • STAMFORD, CONN.

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FIELD OFFICES: Philadelphia • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Kansas City • Los Angeles • San Francisco • Seattle

The BODINE line—
a complete line of fractional hp motors

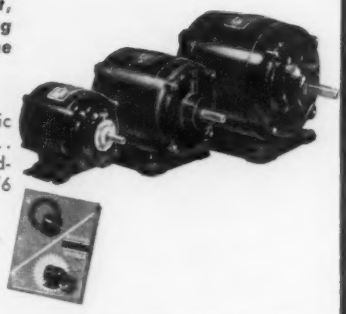
More than 3500 standard built-to-order motors

...for blowers, pumps, coin-handling units, communication equipment, therapeutic devices, sound-recording and reproducing equipment, machine tools, and similar applications

BODINE TYPE N MOTORS

These motors are available in three basic sizes... the smallest 3⅜" in diameter... the largest 5½". Almost any type winding. Standard ratings from 1/150 to 1/6 hp at 1725 rpm.

Write for bulletin "S"



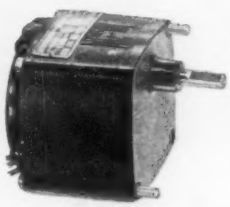
...for instruments, timing devices, control apparatus, and related equipment

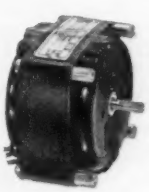
BODINE TYPE K-2 MOTORS

Available with and without speed reducers. Model without reducer ideal for equipment requiring relatively low output. Overall height only 2⅜". Instantly reversible. Can be stalled indefinitely. Synchronous or non-synchronous. Normal 60-cycle output ranges from 1/2000 to 1/500 hp on continuous duty.

Models with parallel shaft speed reducer have high starting torque of not less than 150% of full load torque at room temperature. Quickly reversible under load. Synchronous or non-synchronous. Drive shaft speeds range from 300 to 0.7 rpm...torque ratings from 1.3 in. oz. to 120 in. oz.

Write for bulletin 1024A
...for speed reducer models, bulletin 1023B



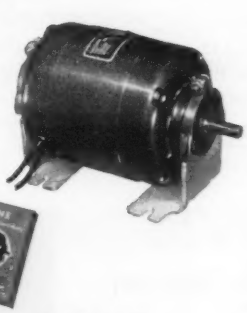


...for use in office machines, automatic phonographs, circulating pumps, air conditioning equipment, and similar applications

BODINE TYPE U MOTORS

"U" type motors are available in 1/20 and 1/15 hp at 1725 rpm...and in 1/30 hp at 1125 rpm. Diameter 4⅜". Split-phase construction. Resilient mounting for quiet operation. Thermal overload protection.

Write for bulletin 1028



295 different stock types and sizes ready for fast shipment!

BODINE ELECTRIC CO., 2508 W. BRADLEY PLACE, CHICAGO 18

BODINE
fractional / horsepower
MOTORS

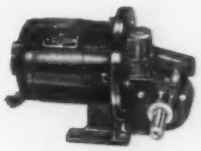
...the power behind the leading products

BODINE SPEED REDUCER MOTORS

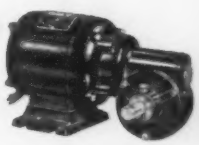
...combines motor and speed reducer in one unit, eliminating all cumbersome and complicated speed reducer transmissions such as belts, gears, and chains

...single or double reduction speed reducers for transmitting low torques over a wide range of speeds. Height, 3⅝".

...double worm-gear reducer to deliver moderate torques at low speeds. Height, 4¾".

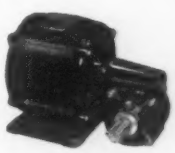


...single reduction, right angle worm gear reducer to deliver moderate torques. Height, 4⅞".



...double worm-gear reducer for transmitting high torques at low speeds. Height, 6⅞".

...single reduction, right angle worm gear reducers for transmitting substantial torques. Height, 6¼".



...heavy duty reducer for continuous driving of heavy loads. Ample reserve for overloads. Height 7⅞". Eight different windings.

Write for bulletin 10228

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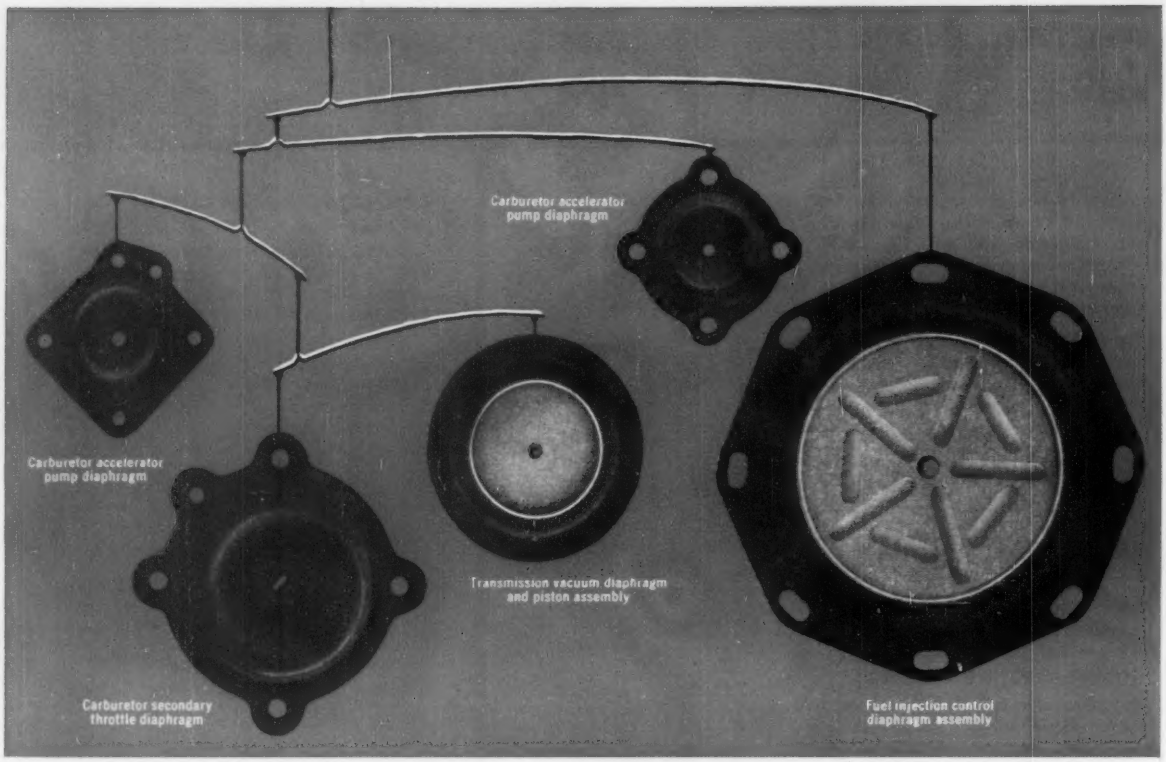
Carburetor accelerator pump diaphragm
Carburetor accelerator pump diaphragm
Transmission vacuum diaphragm and piston assembly
Carburetor secondary throttle diaphragm
Fuel injection control diaphragm assembly

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Simple or complex, your diaphragm problem can be solved quickly, dependably with the help of C/R Sirvene engineers. Their specialized experience gained in the solution of hundreds of similar problems is yours to use. They will design and compound the correct elastomers to produce the exact degree of hardness, tensile strength, compression set, volume change and flexibility you require. Temperature resistance, with various materials, ranges from —100° to 500°F., and compatibility with an equally broad range of fluids, gases and solids, including petroleum base fuels and synthetic hydraulic oils can easily be achieved.

Whether you specify critical tolerances, exact concentricity or flawless bonding—the more reason to assign full responsibility to C/R Sirvene engineers. They'll assure the absolute uniformity and quality of your diaphragm straight through production. Define your diaphragm problem to us and see how we can help.

Write for your copy of the illustrated Diaphragm Bulletin SD-100.

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CHICAGO RAWHIDE

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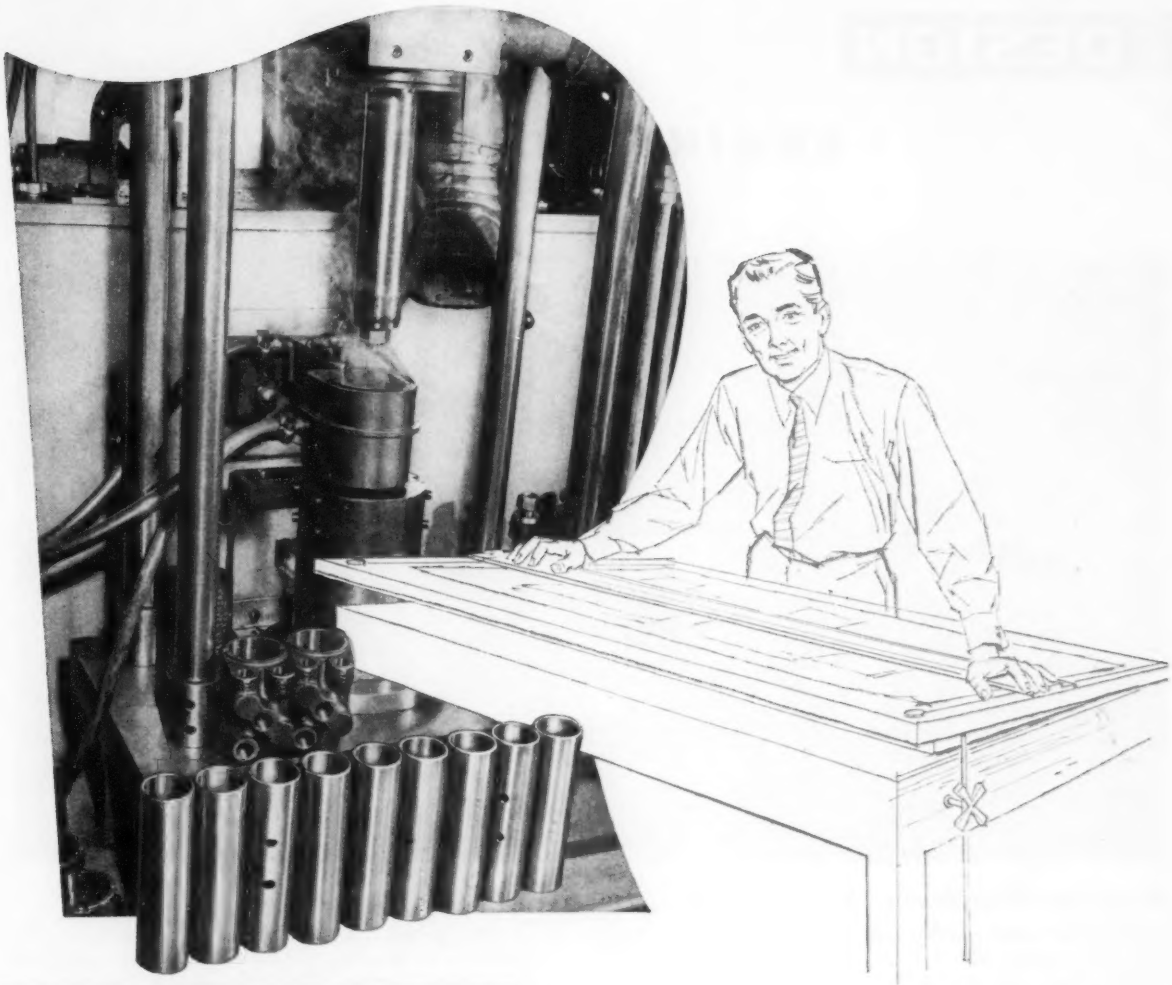

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As a design engineer for hydraulic applications, I find that B&W Welded Carbon Steel Mechanical Tubing with special smooth ID finish offers outstanding benefits. The finished condition in which it comes to our plant reduces costs by eliminating a number of fabricating operations."

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Ask Mr. Tubes, the B&W specialist—he can help you with any tube problem—or write for bulletin TB-428. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

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ENGINEERING NEWS

Moon Dust Won't Swamp This Space Home

Designed for worst possible moon conditions, this 340-foot aluminum prefab will float at anchor on a sea of dust. Providing all "city conveniences," the station will protect residents from the rigors of lunar environment, including bombardment from gnat-like meteorites, radiation, intense heat and cold (+214 F at lunar midday to −243 F at midnight). The slightly arched meteorite shield is pierced only by the plastic-domed control tower. Because of the intense ultraviolet radiation which would discolor glass or plastic, this dome and the observatory bubble (near end) are the only windows, and they're protected by retractable metal screens. Entered through an air lock, the interior of the building is held at 10 psi, roughly the level in present-day pressurized airliners. Dr. John S. Rinehart, Colorado School of Mines, who gave technical direction to the design, predicts a moon station in ten years. Wonder Building Corp. of America, Chicago, recently exhibited this model to Washington officials.

Engineer Shortage? NSPE Says No

Quality and Professional Status Are by Far the Major Problems

SAN FRANCISCO—Dire predictions and rumors concerning the so-called engineering shortage are a disservice to the nation and the engineering profession because they are not based on sound analysis.

Misguided neutrality on the part of industrial management regarding the unionization of engineers could result in a complete breakdown of the concept of professionalism in industry.

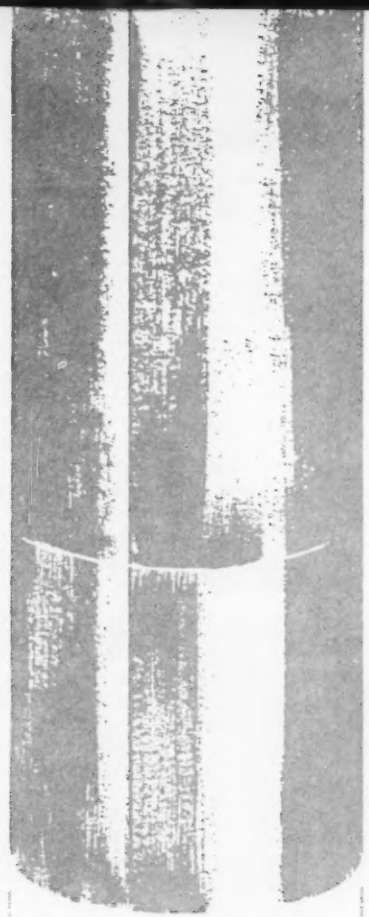
These are the emphatic opinions expressed by the NSPE Board of Directors at the fall meeting in San Francisco.

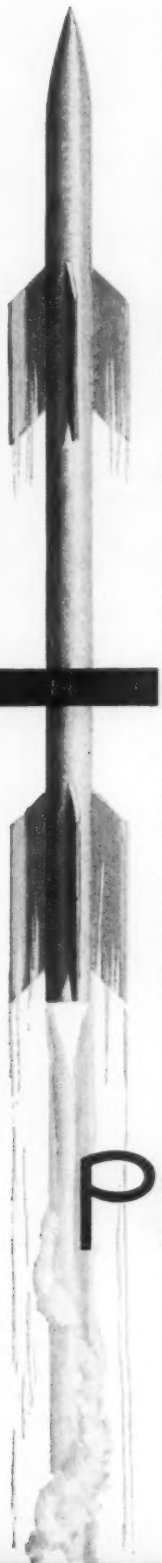
The Board's plea to the Press and industry to stop "adding fuel to the shortage fire," is based on these facts:

- **Engineering school enrollments are at an all-time high and are continuing to increase without artificial stimulation.**
- **Action which may force-feed students into engineering curricula without adequate guidance to the over-burdened engineering schools can only harm the cause of engineering education.**
- **Greater utilization of existing engineering manpower is recognized by all authorities as a first-priority item.**
- **The problem cannot be resolved by merely adding to the number of engineers. The real need is for quality, not quantity.**

In regard to unionization, Dr. Clark A. Dunn, Society president, said in an interview that the "neutral attitude taken by management in some firms when faced with an election among engineering employees on the question of union representation is actually an abdication of management's responsibility in preserving the distinction between professional and nonprofessional services."

Dr. Dunn pointed out that "such an abdication of management responsibility has led to a situation in the aircraft and other industries on the West Coast in which many





Do you know about Gask-O-Seals?

THIS Gask-O-Seal

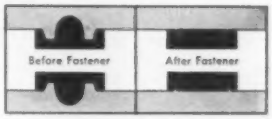
EXCEEDS HERMETIC SPECS!

Gask-O-Seals often equal or exceed specification for hermetic sealing. The one shown here, for instance, has eight sealing points and is on one of our newest missiles. The leakage rate is less than the original hermetic seal specification called for which is about as perfect as any seal can be.

Gask-O-Seals are high and low pressure static seals which require NO groove machining to accommodate. A flat surface with only a 125 RMS surface finish is all you have to provide to get positive sealing with a Gask-O-Seal.

There are many other outstanding features about Gask-O-Seals: Limited area for fluid attack, no loss of structural strength, rigid, easy to install and replace, no tolerance build-up possible in seal cavity, etc.

Why not find out about Gask-O-Seals and the other seals of Parker Seal Company's "O-Seal Family"—by the makers of Parker O-rings.



Parker SEAL COMPANY

CULVER CITY, CALIF. • CLEVELAND, 12, OHIO

A DIVISION OF Parker Hannifin CORPORATION

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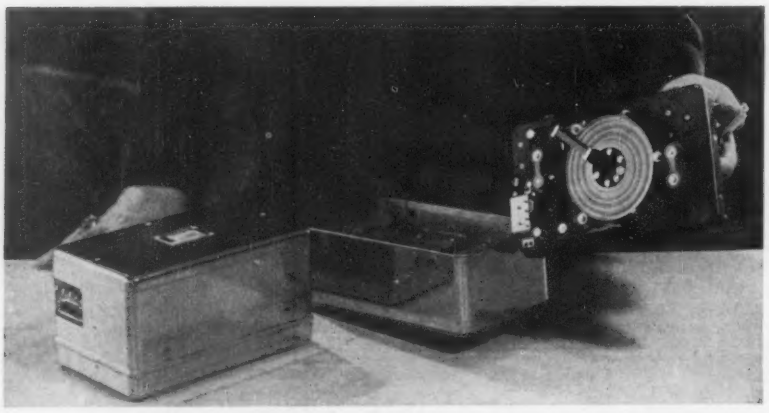
Circle 407 on Page 19

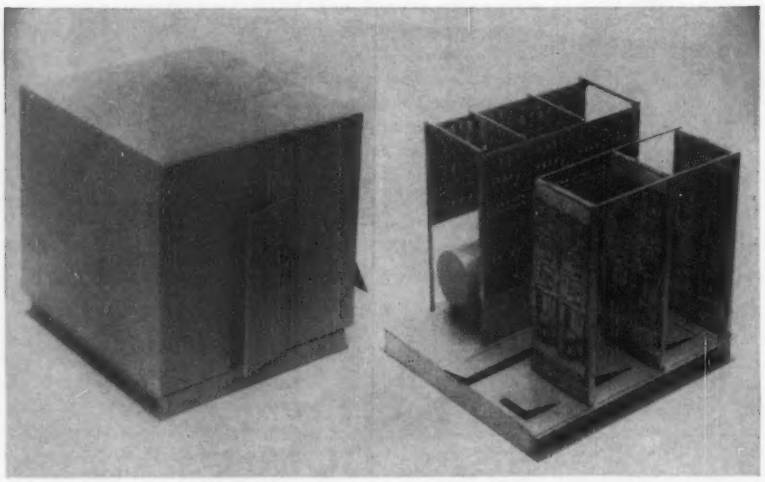
young engineers have never heard an expression of support concerning professionalism from employers."

In other significant developments, James N. Landis, president of ASME told the Board that the AIEE functional plan for unity was not acceptable to the majority of the presidents of the founder societies. The proposal would assign technical responsibilities to EJC, educational subjects to ECPD, and professional duties to NSPE.



Tiny Hi Fi Plays Back Data Fast

Using a closed loop of tape 600 ft long, this rugged little recorder will print two tracks of information simultaneously at 1.25 ips for any interval up to 96 minutes. After playing back information on command signal at 7.5 ips (6 times recording speed), the unit is ready to collect more data. The 8-lb unit, which measures 9 in. long by 5 in. by 4½ in., is designed to take the rigors of space travel, including accelerations up to 50 g, and orientation in any direction. It is the first such recorder to be equipped with a synchronous motor, making possible an exact time reference for its data signals. The whole electronics system calls for only 10 watts of power and is designed so that power is turned on only when the recorder is in operation. Unit was designed by Lockheed's Missile Systems division, Palo Alto, Calif.



Packaged Motor-Control Room

Modular, factory-assembled motor-and-control rooms simplify equipment maintenance and cut installation cost, according to General Electric. Model shows fully-enclosed dustfree room with its complement of ac and dc controls, motor-generator set, motor-operated rheostats, and associated control equipment. Lift-up flooring covers conduits. Basic size of packaged units is approximately 8 ft high, up to 10 ft deep, and up to 20 ft long.

Topics

Which little pig goes to market may some day be determined by ultrasonics. Researchers are now using this means to measure the amount of lean meat on livestock. Penetrating an animal's hide, high-frequency sound waves produce an echo when they strike matter of a different density, such as lean meat or bone. Accuracy is high—in a government research project, an 80 per cent correlation was found between the ultrasonic measurements and actual measurements of meat after slaughtering. Ultimately, the process could enable farmers and ranchers to save their leanest stock for breeding.

• • •

Uncle Sam may want you to serve as a "tax engineer." The Internal Revenue Service says engineer revenue agents are needed in cases involving "engineering issues" such as various aspects of depreciation, depletion, industrial management, valuation, etc. Anyone who accepts the fact that he can't beat 'em and is interested in joining 'em can get a pamphlet on the subject from the Assistant Commissioner (Technical), Att: T:S:E, Internal Revenue Service, Washington 25, D. C.

• • •

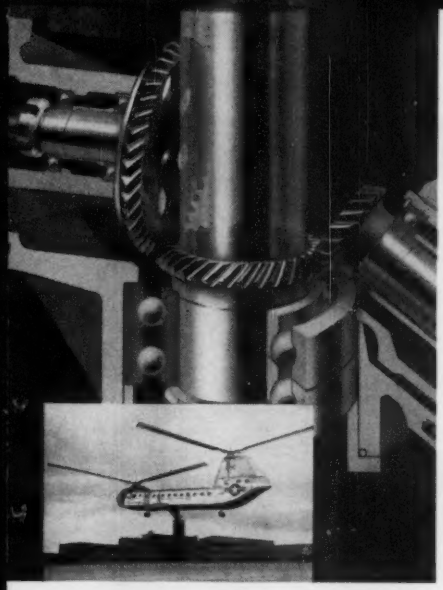
Bad news for rural party-line eavesdroppers is one of the features of a new telephone system: Only the party called hears a bell. The system, developed by Kellogg Switchboard and Supply Co., provides eight voice channels on one pair of wires. Small batteries mounted on a pole near the subscriber's house keep his phone in service even when storms knock out power lines, and an electronic unit automatically strengthens voices to compensate for line noise.

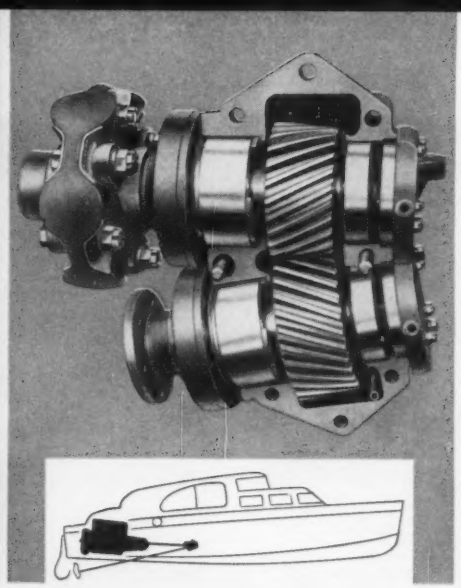
• • •

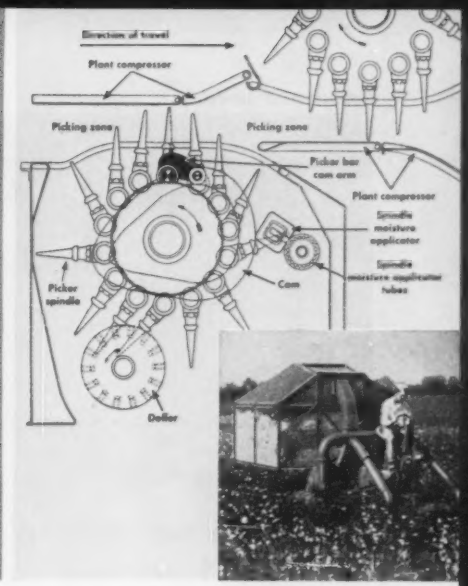
Sweetest gun in the East is the one invented by a New York electrician to shoot out portions of ice cream. An electric heating unit in the wall of the dispenser's barrel heats instantly when the trigger is pulled and cools quickly. In operation, the barrel is warmed and plunged into ice cream for filling; the ice cream cools the barrel, and the gun is removed. Pulling the trigger a second time warms the barrel again and releases the ice cream for serving.

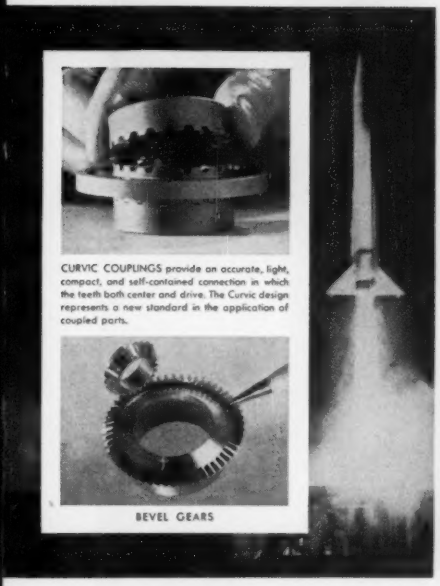
• • •

The best-dressed button-pusher will wear a snug glove, according to findings of the Air Force. A study conducted at Wright Air Development Center, Dayton, Ohio, measured characteristics affecting speed of operation of instrument controls by gloved hands. Snug gloves proved best. Results of a parallel study indicate that a horizontal arrangement of pushbuttons is best.



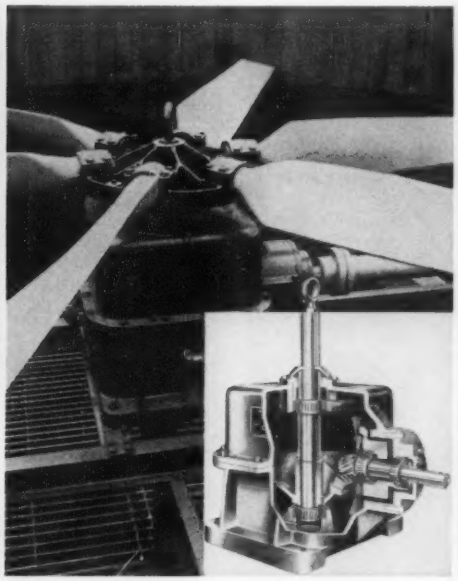


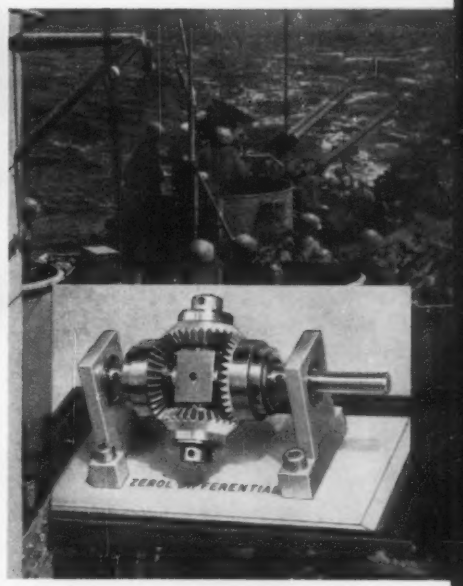




CURVIC COUPLINGS provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.

BEVEL GEARS





What happens when you use right angle or angular drives?

More flexibility. Instead of designing *around* your transmission, you can design a transmission *into* your products with angular drives.

The *helicopter*, for example, is made more compact by having a single drive source service both a blower and a pump. The drive on the *speedboat* gives better balance and more usable cabin space. The *cotton picker* runs fourteen separate picking spindles off one drive member.

Greater accuracy. Using Gleason machines and methods you can grind or cut bevel gears to exceptionally close tolerances. The complete accuracy and reliability needed in the *missile* and *fire control unit* are obvious.

Heavier loads. An angular drive can stay compact and still carry heavy loads such as the one on the gear reducer in the *cooling tower fan*.

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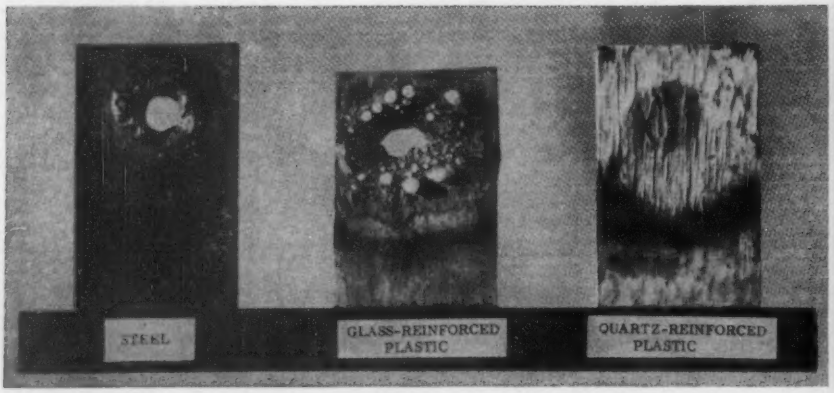
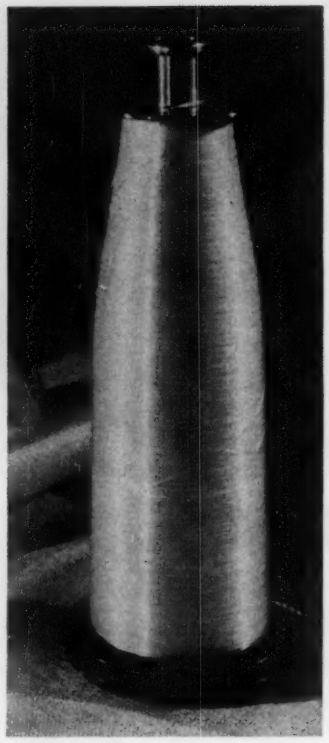


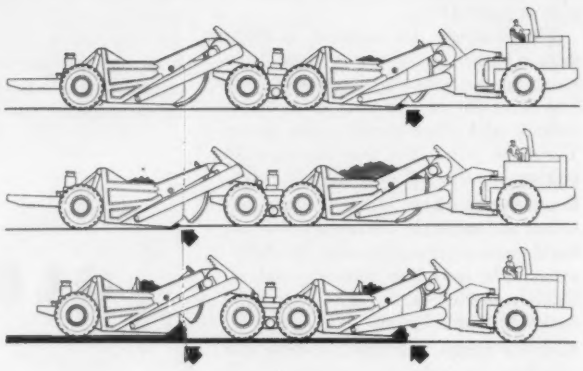


Pure Quartz Thread Reinforces Hot Plastics

Thread and cloth made of pure fused quartz boost the strength-to-weight ratio of many plastics now used in rockets and missiles. In high-temperature applications, quartz reinforcing has also permitted use of many plastic components in the place of metal, with a weight saving of 10 to 1. Developed by General Electric, the unique material is first produced in continuous 0.0005-in. diameter monofilaments of pure quartz. Several hundred single strands are then twisted, plied into yarn, and woven into fabric. In flame tests, above, equal-thickness panels of steel, glass-reinforced plastic, and quartz-reinforced plastic were burned with an oxyhydrogen torch for 40 sec. The intense heat—over 500 F—melted and burned through both steel and glass-reinforced plastic in less than 40 sec. Quartz-reinforced plastic withstood the flame and retained its structural strength. All thread has been allocated to military so far, but GE is studying civilian use.

Biggest Dam Builder of Them All

New holder of the world's-largest-earthmover title is this 100-ft long, 130-ton capacity dam builder and canal digger built by R. G. LeTourneau. Like the former champ—a 70-ton capacity LeTourneau machine introduced just 6 weeks ago—the new heavyweight has dc drive motors geared to the rims of all eight wheels. Ac motors drive various controls. Two 600-hp diesel engines power the ac and dc dynamos. During load and spread operations, right, front bucket scrapes up 65 tons of dirt while empty rear bucket, with motor in each wheel, serves as an auxiliary pusher. Rear bucket then scoops up the same amount of dirt, aided by traction of the loaded front bucket. In emptying the load, spreads can be single or double depth. According to LeTourneau, 86 of the new earthmovers working two shifts could dig a second Panama Canal in 3 years. With previous equipment, job would require 400 machines.



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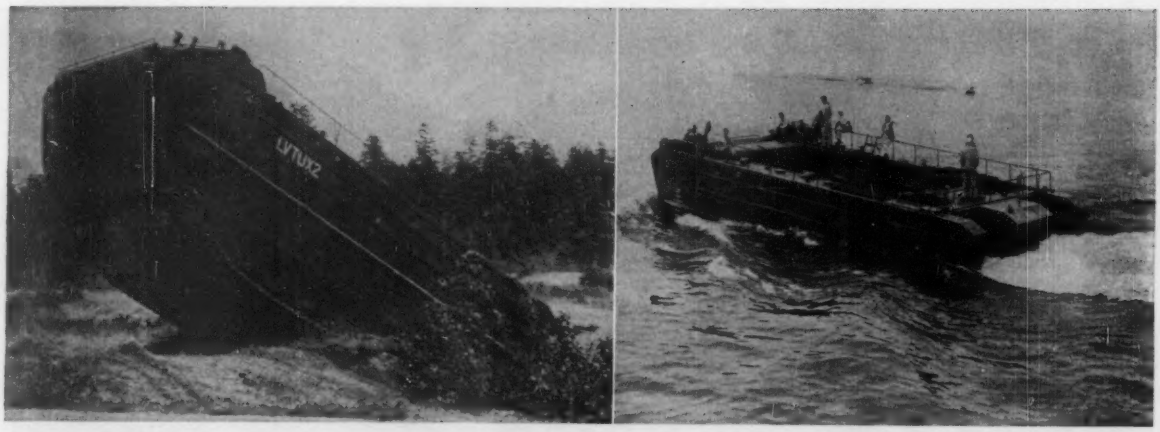
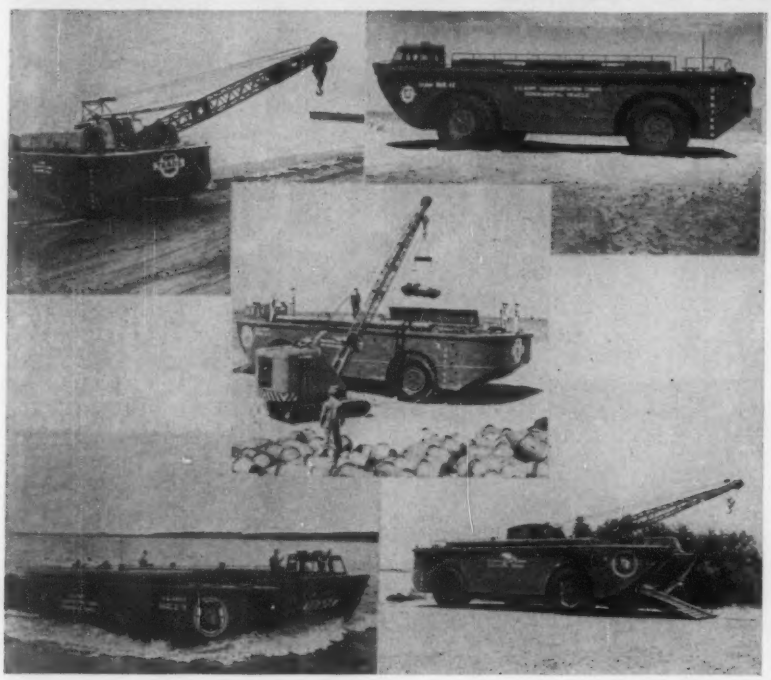




Army, Navy Test Big Amphibians

Navy's 100-ton Goliath, above, has two retractable propellers for traveling through water and four independent rubber-bushed tracks for crawling on land. With a capacity of 63 tons, the big craft can transport any tank now in military service. Two 500-hp diesel engines push the fully-loaded hull through water at 7 mph, or provide a maximum land speed of 13 mph. Built by Pacific Car & Foundry Co., the experimental Goliath is 46 ft long, 14½ ft high.

Army's 100-ton Barc, left, is a versatile amphibious lighter capable of hauling 100 tons. Bigger than Goliath, the all-purpose craft is 61 ft long, 26 ft wide, and 19 ft high. Four 200-hp diesel engines with torque converters power twin propellers in water, four wheels on land. Maximum water speed is 7 mph; land speed, 15 mph. Selective front-rear steering permits crabbing. Barc's draft is 3 ft empty, 5 ft, 7 in. loaded. Army Transportation Corps designed the craft.

Hypersonic Wind Tunnel Holds Peak Velocity Ten Hours

Vacuum Caused by Frozen Gas Provides Sink for Fast Flow

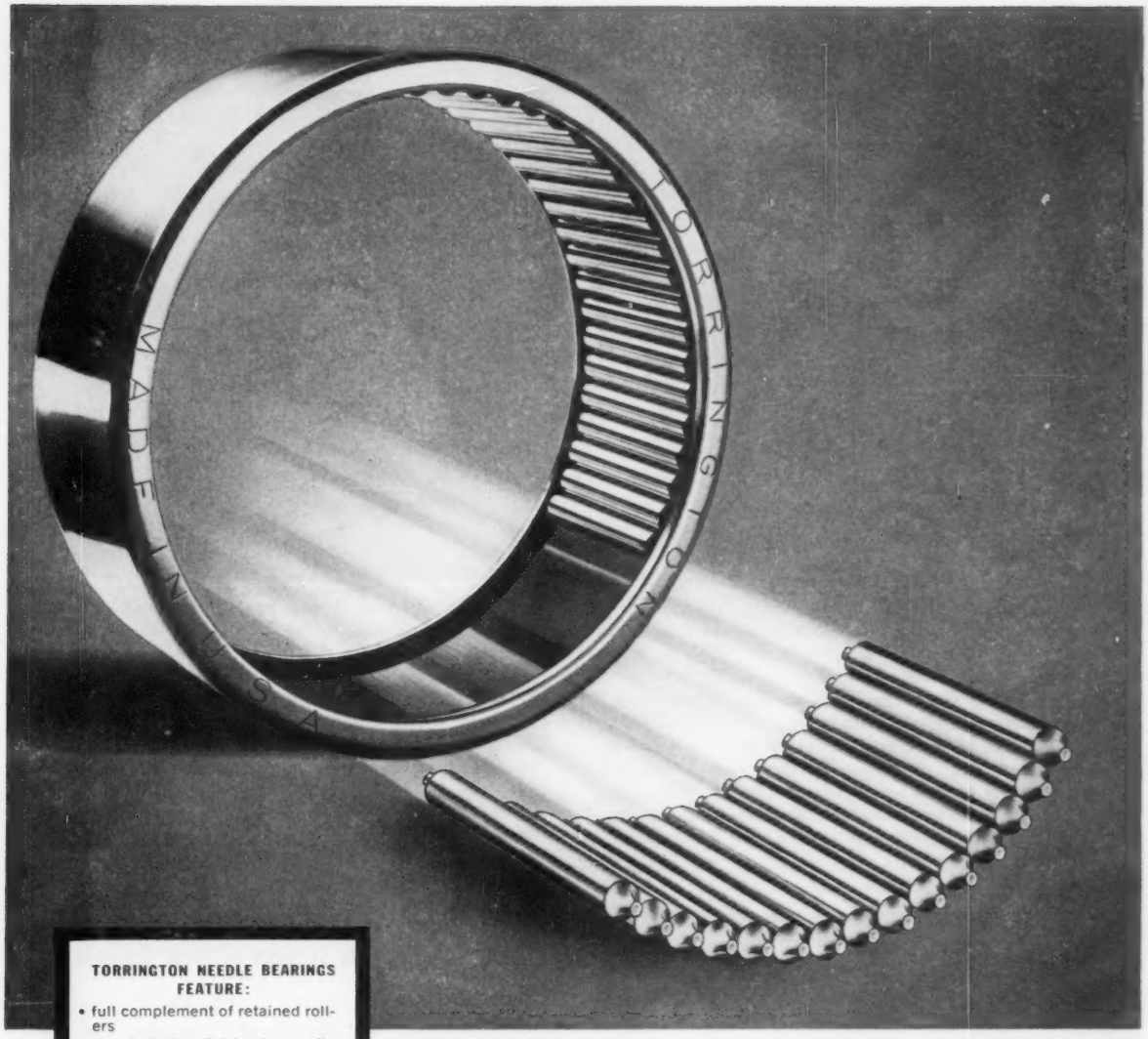
CAMBRIDGE, MASS. — To maintain hypersonic flow for ten hours, a new wind tunnel uses a unique flow sink instead of the conventional pump. In an atmosphere of nitrogen gas, used to avoid moisture problems, expansion coils operating at −420 F freeze out nitrogen, making a high vacuum which draws the gas through the tunnel to simulate Mach 20 conditions at 300,000 feet.

The refrigerating unit, called Cryopump, uses helium which boils at −452 F for a refrigerant working through a 50-hp compressor. This and a conventional 5-hp diffusion pump used to start the cycle are the only moving parts.

To duplicate the achievement with conventional equipment would take a city block full of fans and pumps consuming more than 500,000 hp. Most hypersonic equipment can maintain peak velocity and altitude for only a fraction of a second. Cryopump was designed by Arthur D. Little Inc., Cambridge, Mass. Wind tunnel is operated for the Air Force Office of Scientific Research and the Office of Naval Research by the University of Southern California.

AF Sees Infrared in New Light

WRIGHT-PATTERSON AIR FORCE BASE, OHIO—Coated silicon-crystal "windows" transmit better than 90 per cent of incident infrared (IR) light of four to five-micron wavelength to substantially improve IR detection and guidance systems efficiency. Not only is transmission better, but a broader band of the wave spectrum than ever before possible can now be used, according to Air Force specialists. Possible civilian uses include anticollision and other detection devices. Development was sponsored by Manufacturing Methods Div., Air Materiel Command, Wright-Patterson A.F. base.



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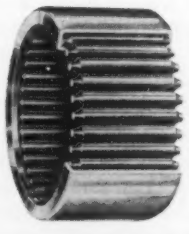

Here's Why Torrington Needle Bearings Provide Maximum Radial Load Capacity

The Torrington Needle Bearing's full complement of small diameter rollers provides the largest possible number of bearing contact lines in the load zone.

This feature gives Needle Bearings a higher radial load capacity than any other bearing of comparable size. Precision rollers ensure smooth anti-friction performance with low coefficient of starting and running friction. to match this unequalled capacity. Rollers are positively retained by the turned-in lips of the outer shell, permitting simple, economical installation and assembly.

Torrington experience spans twenty years in design and application of Needle Bearings to equipment of all types. This experience is at your disposal to help you secure the ultimate in performance built into every Torrington Needle Bearing. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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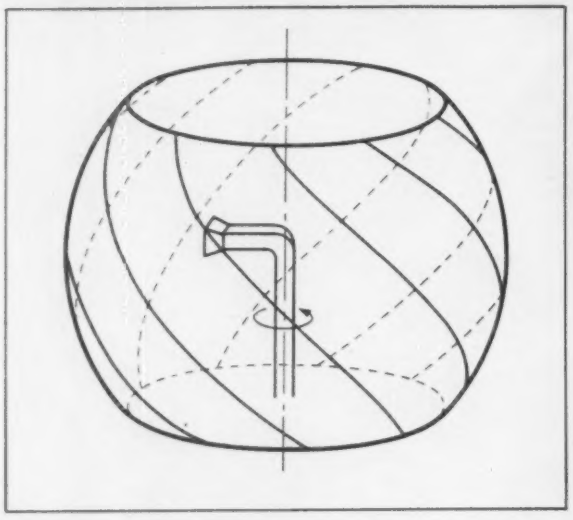
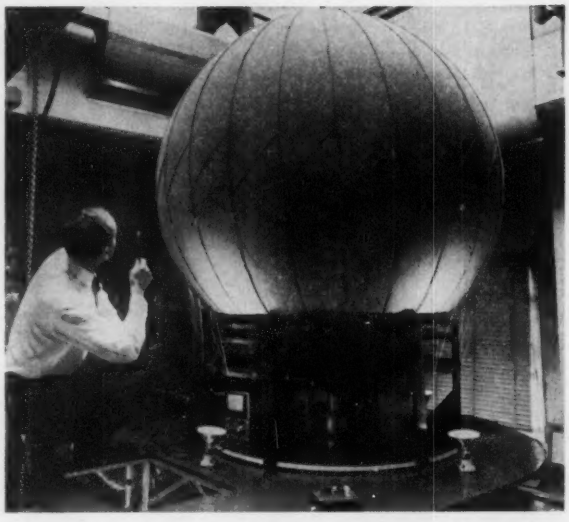
Cloth Balloon Proves New Concept in Radar Antennas





A spherical radar antenna that scans 360 deg without actually rotating may be used with powerful new antimissile radars. The beam emitted from the antenna is scanned by merely rotating the feed horn at high rpm. Problem of getting the beam out of the sphere was solved by taking advantage of the polarization properties of radar waves: Direction of the electric vector of wave is fixed by the rectangular shape of the waveguide. Acting to reflect or pass radiation from the horn are parallel metallic strips, wound helically around the insulating surface of the sphere. The strips cross the equator at 45 deg, left. If the feed horn is also tilted at 45 deg, strips first encountered by the radiation are parallel to the electric vector, and the wave is reflected back from the inside of the sphere, as in the usual dish-shaped antenna. When the reflected beam hits the opposite side of the sphere, it passes through conducting strips which are perpendicular to the electric vector. Called a Helisphere, the new antenna was developed by Westinghouse. A highly successful 5-ft prototype, right, uses ordinary drapery material containing metallic threads for the sphere. Full-scale spheres, made of different material, would be 50 to 100 ft in diameter.

German Prinz

New in the U. S. and Germany, the four-passenger Prinz is powered by a rear-mounted two-cylinder (vertical twin) engine rated at 26 hp. The engine is air-cooled and is packaged as a single unit with gears and differential. Fuel consumption ranges to 55 mpg; top speed is about 70 mph. The car is mounted on a 78¾-in. wheelbase, has an overall length of 123¾ in., and is 54 in. high. It weighs 1080 lb. Rack and pinion steering, 12-v electrical system, and unitized body-frame are major features. Prinz is built by Europe's largest producer of two-wheeled vehicles—NSU Werke AG, West Germany—and is the recent winner of the Eiffel mountain race sponsored by the German Automobile Club. P.O.E. price of a standard Prinz: $1398. Folding-top deluxe model costs more.

Radiation Effect on Steels Is Subject of New Research

Study Will Seek to Determine Nature of Crystalline Change

PITTSBURGH—Research aimed at determining the effect of nuclear radiation on standard steels and new steel alloys is expected to provide improved steels for valves, pumps and other nuclear-reactor components. United States Steel Corp. and Nuclear Science and Engineering Corp. have joined forces to carry out the research project.

Samples of various alloys will be first subjected to high neutron and gamma fluxes in a reactor. Crystalline structure of the samples will then be studied by electron microscopy to determine grain structure and inclusions precipitated at the grain boundaries.

Since contaminated steel samples would be unsafe to handle, plastic replicas of the polished surfaces will be made for detailed examination by scientists.

Electronic Calibration Center Opened for Business by NBS

Urgently Needed Services Can be Provided Now

BOULDER, COLO.—National Bureau of Standard's recently dedicated Electronic Calibration Center is providing government, industry, and the military services with access to the nation's primary electronic standards. Here will be calibrated the master working standards which, in turn, are used to calibrate instruments on production lines and in research laboratories.

The new facility will help the Bureau meet the steadily-increasing need for more precise electronic standards and instruments.

Services offered by the Calibration Center cover three broad frequency ranges: 1. Low-frequency (zero through about 30 kc). 2. High-frequency (30 kc through about 300 mc). 3. Microwave (above 300 mc).

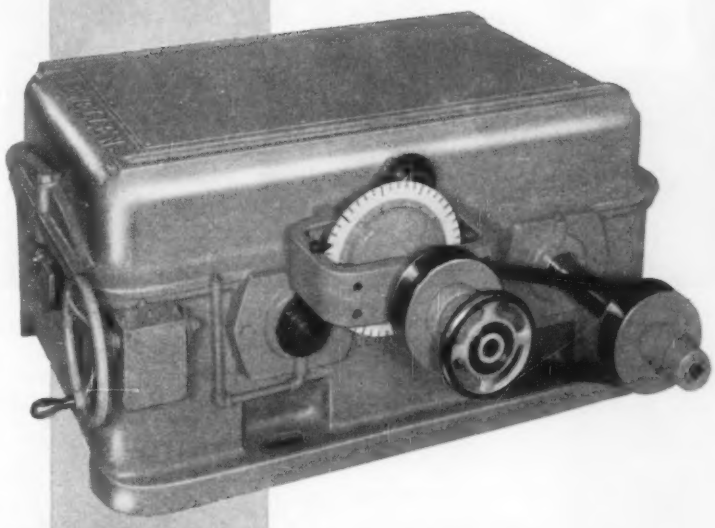
In the low-frequency region, the Electronic Calibration Center provides calibrations for electrical standards such as resistors, bridges, potentiometers, inductors, capacitors, standard cells, electrical instruments, ratio devices, and instrument transformers. These services previously have been available only through the NBS Electricity and Electronics Division in Washington. They will continue to be available there, as well as in Boulder.

In the h.f. region the Center is being equipped initially to calibrate standards of voltage (unbalanced), power, impedance, attenuation, and field strength. These standards are limited at present to those designed for continuous-wave measurements.

For most parameters, calibration services are planned primarily for the nine fixed frequencies of 30, 100, and 300 kc, and 1, 3, 10, 30, 100, and 300 mc. In addition to the fixed-frequency apparatus, continuous frequency coverage is being provided wherever feasible. This equipment will be less stable and less accurate, however.

Microwave facilities at the Center will measure attenuation, power, frequency, and impedance. The frequency range to be covered extends from 300 to 40,000 mc for attenuation, power and impedance calibrations, and to 75,000 mc for frequency calibrations.

Minute-Measurable Speed Variation



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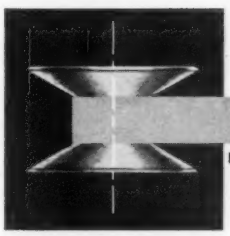

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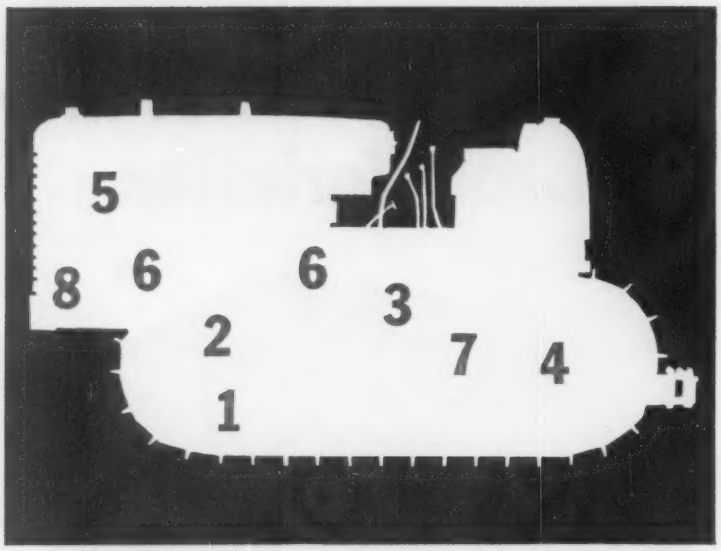
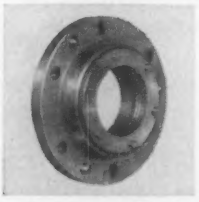


ROTARY SEALS are in every-day, heavy-duty service at key points on well-known tractors

1. TRACK ROLLER SEAL . . . Self-contained, entirely unitized cartridge design, for use with plain or anti-friction bearings. For excluding dirt, retaining lubricant.

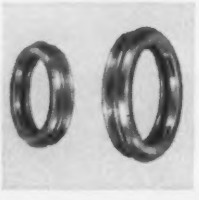
2. FRONT IDLER SEAL . . . Flange-mounted unitized design incorporating bearing thrust plate with Seal assembly for excluding dirt, retaining lubricant.



3. UPPER SUPPORT ROLLER SEAL . . . Completely unitized design, flange mounted, incorporating bearing thrust plate, integral shaft gasket and seal assembly.

4. FINAL DRIVE SEAL . . . A metal-faced, self-contained cartridge, easy to design into present machines with minimum of changes.

5. WATER PUMP SEAL . . . A typical ROTARY SEAL style, highly successful for automotive as well as crawler and farm tractor water pumps. Available in many material combinations to meet a wide variety of uses.



6. FRONT & REAR CRANKSHAFT SEALS . . . Give positive retention of liquid oil and vapors for long sustained usage without replacement, in critical locations in industrial and crawler tractor engines. Specially selected facing materials assure much longer life than ordinary Seals.

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8. HIGH PRESSURE BALANCED HYDRAULIC PUMP SEAL . . . Designed for constant operation under elevated pressures and temperatures. Commonly used at pressures exceeding 1500 PSI.

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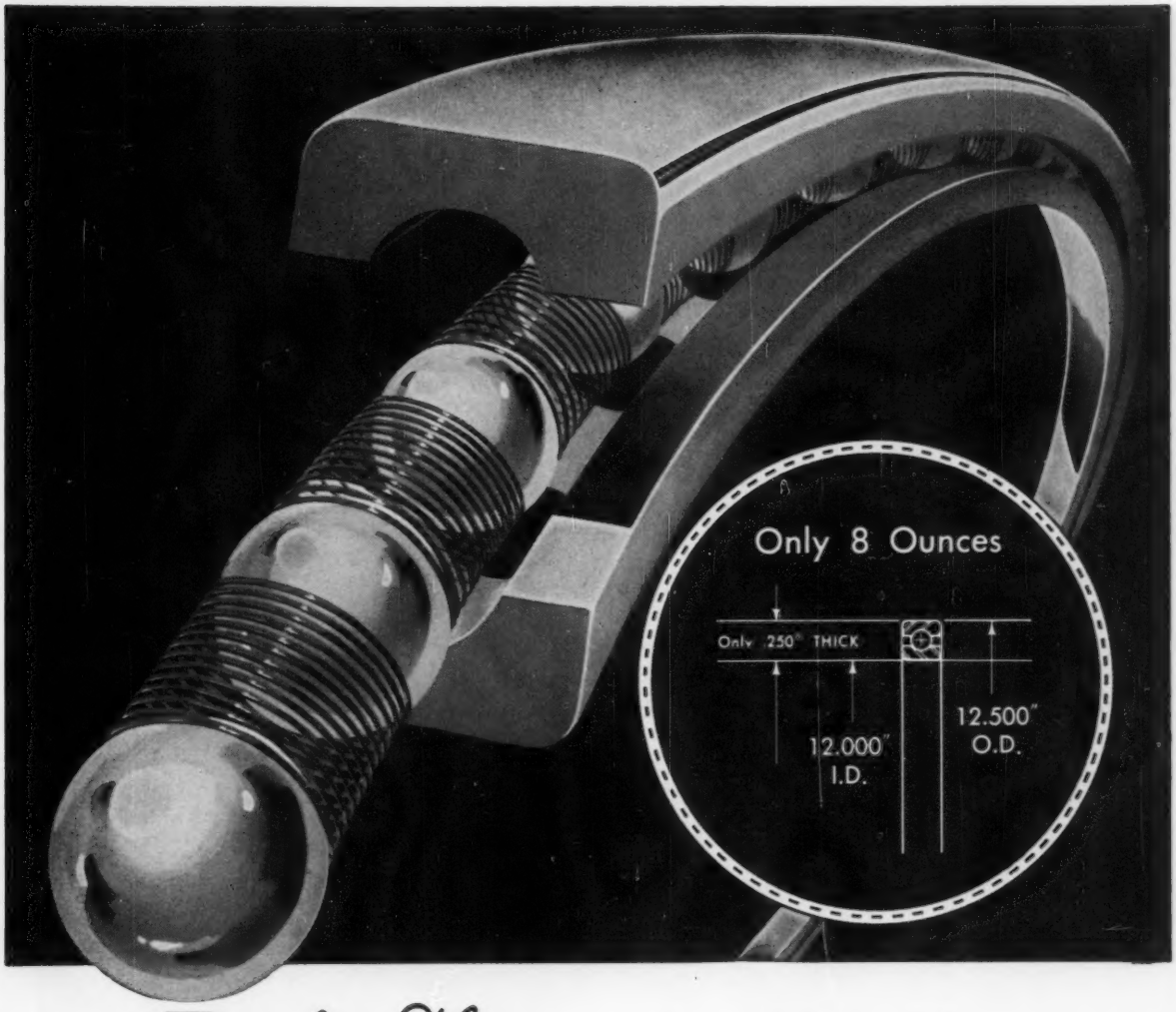

Reali-Slim... by Kaydon
world's thinnest radial ball bearing

HERE'S a typical example of Kaydon's *Reali-Slim* unique radial ball bearing that's finding wide application in practically every industry. *Reali-Slim* are the world's finest thin-section bearings and proportionately are thinner than a wedding ring. The bearing illustrated here is 12.000" I.D., 12.500" O.D., .250" thick — weighs less than 8 ounces. Designed for minimum weight and space limitations, it has a static load capacity of 5,520 lbs. and 894 lbs. at 100 rpm.

If you're looking for *Reali-Slim*, lightweight, radial ball or roller bearings, look at Kaydon's *Reali-Slim* line. Besides hundreds of standard *Reali-Slim* designs, there's a wide variety of special races, seals and separators to meet special bearing problems. What's more Kaydon is able to produce these *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual. In addition, Kaydon bearing engineers are prepared to give you valuable help with technical bearing application problems.

For complete data on *Reali-Slim* bearings for standard or special applications, ask for engineering Catalog **No.54RS-2.**

***Reali-Slim* Ball Bearings** — in Conrad, angular contact, 4-point contact and other types are available in seven standard cross sections from .250" to 1" and in bore diameters from 4" to 40".

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All types of ball and roller bearings — 4" bore to 178" outside diameter...
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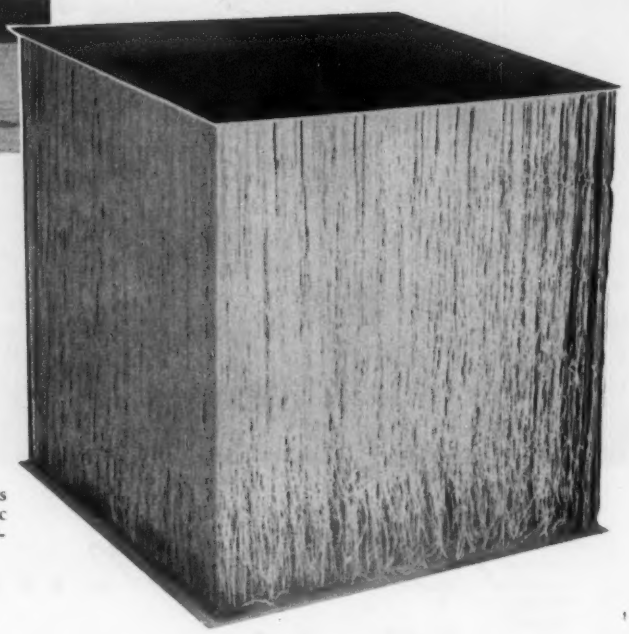
Circle 413 on Page 19

STRUCTURAL

Amphibian
Ski installed over single wheel permits Inflatoplane to operate over land or water. Collapsible craft can attain an altitude of 10,000 ft, cruise for 6½ hrs at 60 mph. Only 300 ft of runway is required.



Airmat cross section
Pneumatic structural material consists of two layers of rubberized fabric constrained, when inflated, by interwoven drop threads.

IN A SMALL HANGAR at the Goodyear Aircraft Corp., Akron, Ohio, assemblers are putting the final touches on ten strange-looking airplanes. The planes' surfaces feel like rubber sponges, and the first-time visitor wonders what it's like to fly a plane made of inflated sandwiches of rubberized fabric.

But the Inflatoplane is far more than a spongy curiosity. It represents the latest engineering application of Airmat, and follows 15 years of Goodyear development work on inflatable structural panels.

Inflatoplane answers the military need for a collapsible airplane with conventional airfoils which can be paradropped to a downed pilot, behind enemy lines, to be reassembled and in the air in 6 or 7 minutes.

Design for inflation

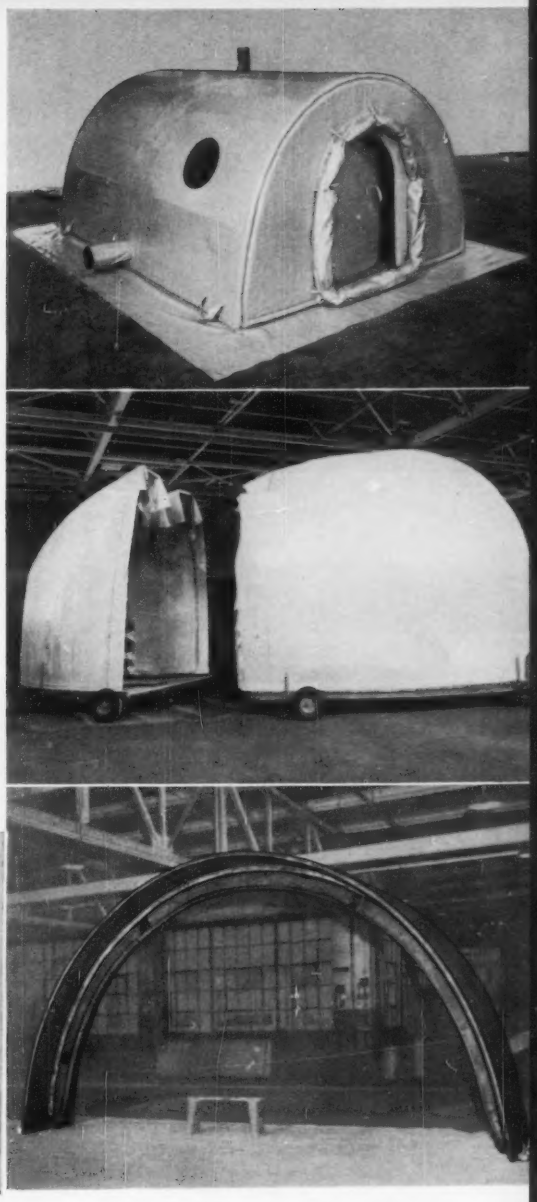
Basic building block of the Inflatoplane is Airmat, a pneumatic structural material. Flat Airmat panels have an impressive history of success as load-carrying members in collapsible structures. When inflated, each panel consists of two sheets of multilayer fabric held a fixed distance apart by interconnecting tie yarns. In the process of weaving, the continuous tie yarns are dropped from the face of one cloth to the other, looped over several of the fill threads, passed back to the first cloth, looped over several of its fill threads, etc.

Afterwards, the cloth is coated on its outer sides with a rubberizing sealer and then covered with more cloth and sealer to form airtight surfaces. The inflatable section can be made from a number of different materials, including nylon, Dacron, and cotton. Flat panels have been made as thick as 15 in. with no appreciable difficulty.

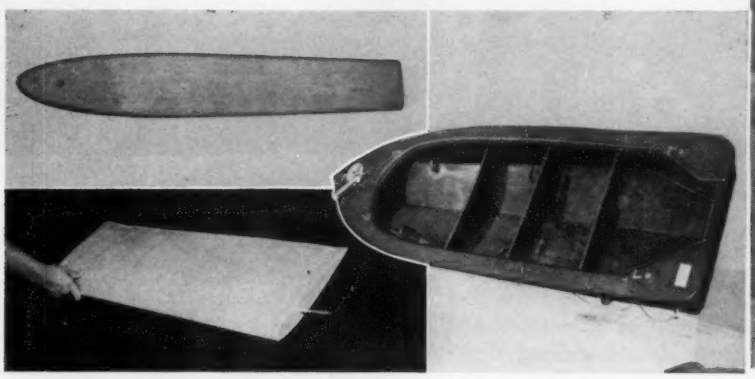
Inflating these panels places the fabric walls in tension. When used as a structural member, the beam strength of any one section is de-

AIR

packaged in inflatable sandwich panels, offers highest strength-to-weight ratios in shelters, boats, and planes



Airy products
Six Airmat products shown here include four-man Arctic shelter, two-section jet-maintenance shelter, arched beam for Quonset-type shelter, ten-man boat, surfboard, and airfoil.



termined by its limiting skin stresses. How failure occurs is interesting.

Because the entire surface of an inflated Airmat section is in tension, it is the antithesis of the prestressed concrete beam, where the entire surface is under initial compression. Consequently, the Airmat beam fails when compressive forces on the compression side of the member exceed the tensile forces caused by internal pressure, resulting only in wrinkling or buckling without permanent damage to the structure.

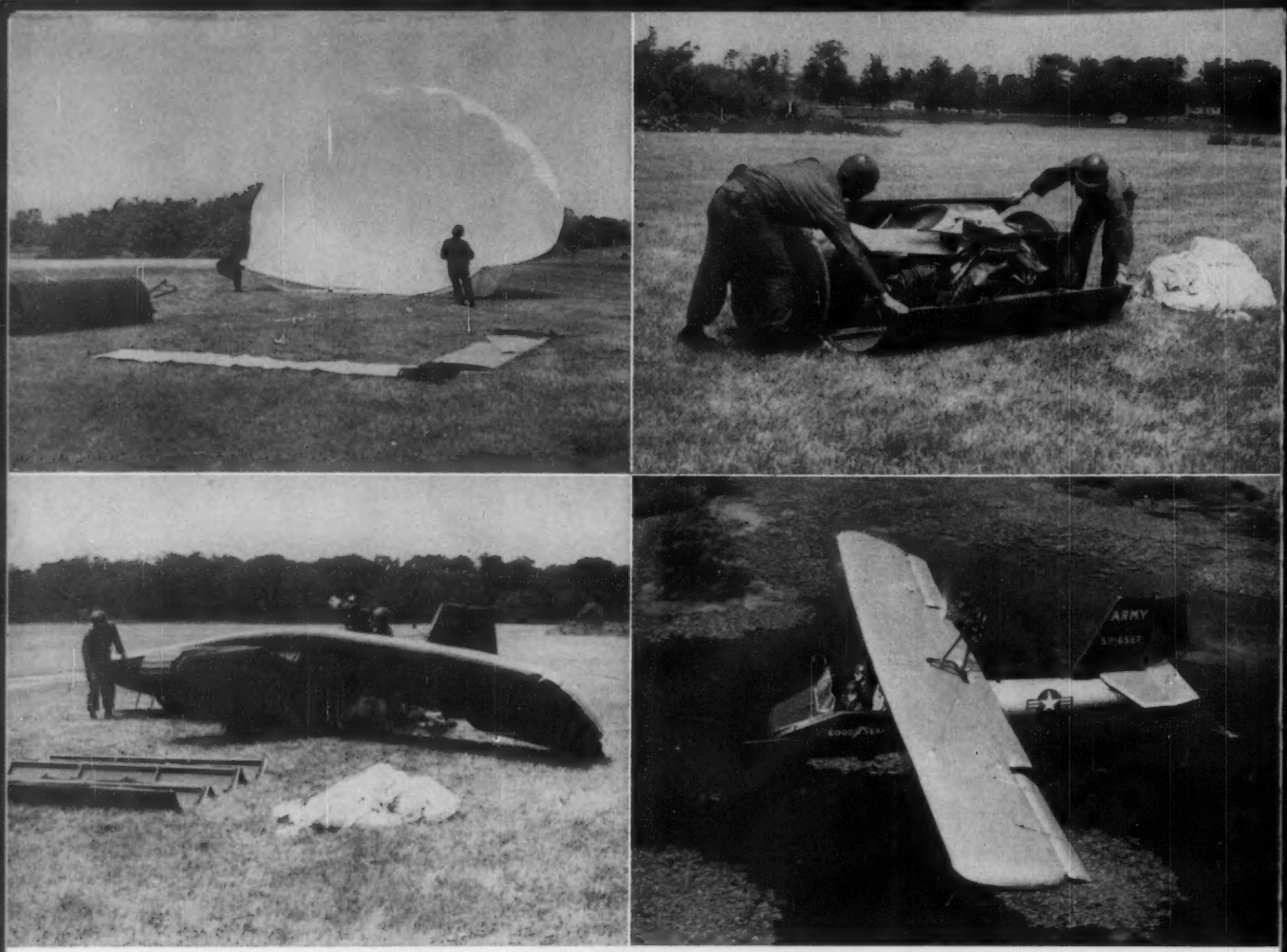
Besides making extensive use of the beam strength of plain sections of Airmat, Goodyear has developed a composite inflatable beam which uses a section of Airmat as the compression member, an attached section of Airmat as a spacer, and a built-in, lightweight cable as the tension part of the beam. This combination beam, according to the company, affords the greatest strength-to-weight ratio of any beam known.

How to weave an airfoil

Newest developments in the weaving of Airmat permit the fabrication of inflatable airfoil sections. This is done by varying the length of drop threads (tie yarns) between cloth layers.

The biggest problem in the use of Airmat structures, points out George Skoda of Goodyear Tire & Rubber Co.'s Aviation Products Div., is maintaining uniform stresses for rectangular configurations. Nonuniform stresses give radial shapes, which are the forms of least resistance. The same nonuniform stresses, however, can be used for contoured sections. Attainment of production of wing configurations for Inflatoplanes marks the first successful attempt to produce Airmat that is contoured rather than flat.

"We are still in development so far as airfoil sections are con-



Air to air Two-place Inflatoplane, with greater wing area and larger engine than one-place model, is shown paradropped, unpackaged, inflated, and in the air. Entire time, from package to flight, is estimated at 6 minutes.

cerned," says Skoda. "We can now make conventional symmetrical airfoils such as NACA 0015, but are limited by present equipment to 48-in. chords. Of course we can make multisection structures. We are also approaching a tapered wing with a symmetrical airfoil, which corresponds to a conventional wing, and we are even considering making a delta wing from Airmat fabric."

On land and sea

Inflated air sandwiches also find extensive use in boats, military shelters, as enclosures for the servicing of large jet engines, as working platforms that distribute load, even as surfboards. To the military, the advantage of portability is obvious.

Boats of Airmat material are a natural since they offer inherent buoyancy. Units recently delivered to the Bureau of Ships each hold 10 persons, are 16 ft long, 6½ ft beam, and have built-in provisions for mounting a 35-hp outboard motor. Their boat-within-a-boat construction employs two thicknesses of Airmat, each of which has a left and right-hand compartment. All four compartments are inflated with carbon dioxide; bulkhead stiffeners are hand-inflated. In another design, an Airmat deck for a 15-man abandon-ship boat, is an added safeguard. If the boat is damaged, survivors are left with the lifesaving Airmat deck.

Shelters offer many opportunities for design ingenuity, and company engineers have proposed a variety of shelters for military purposes, including portable command, communication, and operational posts, as well as personnel structures.

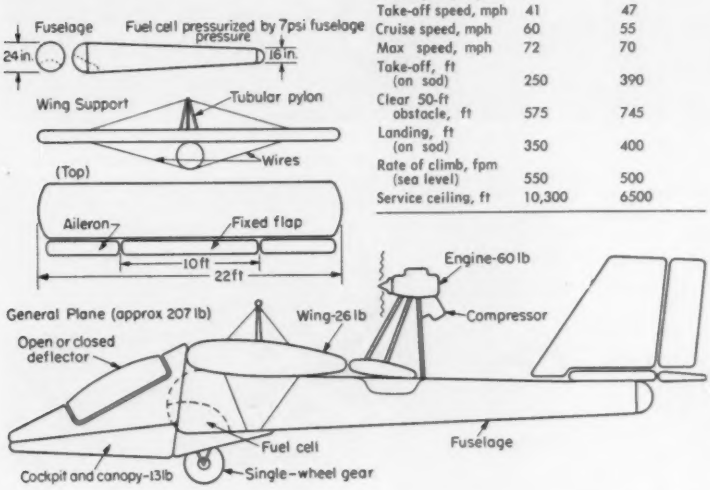
A four-man shelter for the Air Force can withstand heavy Arctic ice and snow loads. Inflated at high pressures, the structure is rigid and the air-filled walls serve as insulation against heat, cold, and vibration. Inside roominess permits the installation of four Airmat bunks.

Maintenance shelter for the Air Force Air Materiel Command simplifies second-echelon maintenance on big bombers under adverse weather conditions. Built in two sections and mounted on mated dollies for maneuverability, the portable shelter fits about the jet pedestals under the bomber wings and completely encloses the suspended pod in a weatherproof structure. Access is gained through a 6 x 6-ft maintenance door in the forward end and a personnel door in the other. An opening at the top where the sections fit together admits the jet pod, and a drawstring arrangement secures the shelter tightly about the pedestal.

Inflatoplane data

Inflatoplane has a spongy feeling to it, but handles like any conventional light, fixed-wing aircraft. Air lost or valved in flight is replenished by engine-driven compressor. Initial inflation may be accomplished by three methods: 1. Bottled compressed air. 2. Portable engine-driven compressor. 3. Hand pump of large displacement (15 min. estimated inflation time). Airmat must be evacuated before packaging, either by hand or powered vacuum pump. Intake manifold of car or vacuum sweeper may also be used.

ITEM	ONE-PLACE	TWO-PLACE
Wing span, ft	22	28
Wing area, sq ft	110	154
Airfoil	NACA 0015	NACA 0018
Length, ft	19.7	19.2
Engine, hp	42 (Nelson)	65 (McCulloch)
Compressor, cfm	27 (Pesco)	27 (Pesco)
Inflation pressure, psi	7	8
Inflation time, min (package to airborne)	5	6
Empty weight, lb	230	290
Personnel, lb	200	340
Fuel, 24 gal, lb	145	112
Gross weight, lb	550	740
Endurance, hr	6.5	5.6
Stall speed, mph	37	43
Take-off speed, mph	41	47
Cruise speed, mph	60	55
Max speed, mph	72	70
Take-off, ft (on sod)	250	390
Clear 50-ft obstacle, ft	575	745
Landing, ft (on sod)	350	400
Rate of climb, fpm (sea level)	550	500
Service ceiling, ft	10,300	6500



Collapsible platform of Airmat, to aid maintenance inside the fuel cell of a B-52 bomber, meets three design requirements. When collapsed, the platform can be easily inserted through the limited-access opening in the cell. When inflated, the platform can support two men, allowing them to service the 8-ft high ceiling of the cell. Also, the bottom surface of the air-filled cushion distributes weight of the maintenance personnel over the entire platform area, thus reducing stress concentrations and eliminating possible damage to the deck of the fuel cell.

Other products of Airmat also suggest interesting design possibilities. A **rotor blade** is being developed for use on helicopters and convertiplanes under a contract with the Navy Bureau of Aeronautics. Inflated Airmat would increase fatigue life of the blade and afford good packaging and storage possibilities. De-icing could be accomlished either by an electrical conductor embedded in the rotor blade, or by varying the pressure inside the rotor blade. A **surfboard** of inflatable material offers easy portability to the water's edge—and fast getaway from it. A **pneumatic jack** of Airmat sections is a product in search of applications.

Back in the air

But by far the most intriguing of all Airmat structures is the Inflatoplane, of which Goodyear Aircraft has developed three versions to date. Present accomplishments lead to forecasts for the future.

"Airmat structures are not limited to low-speed aircraft," says Inflatoplane project engineer, J. Thomas Blair. "We are now carrying on programs for the development of military aircraft in speed ranges which far exceed those associated with the current Inflatoplane."

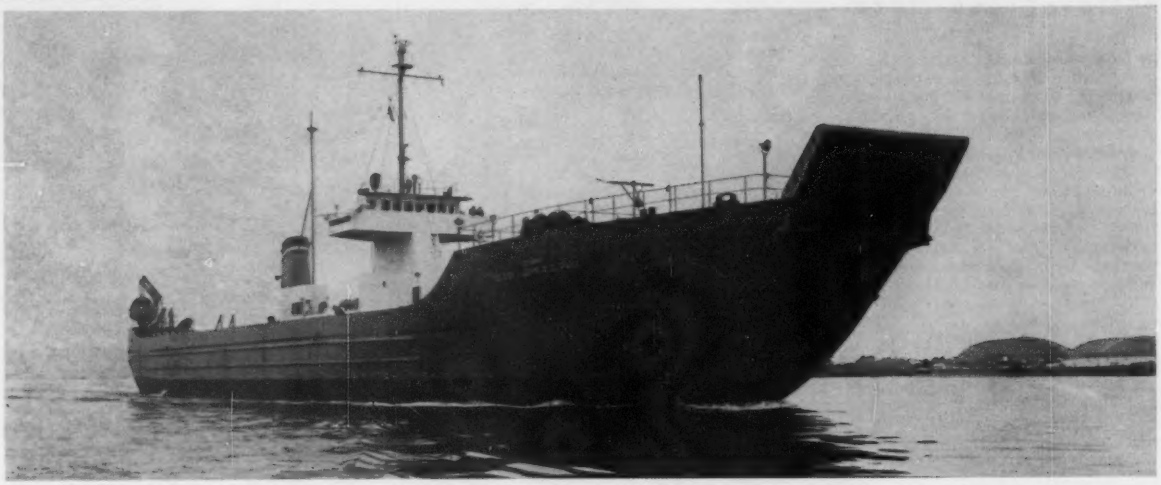
"Cost figures indicate this aircraft, produced in quantity, can be sold at a lower price than any comparable, light aircraft now on the market," says Paul L. Schmitz, in charge of Goodyear Aircraft's heavier-than-air projects, Weapons Systems Div.

He points to military applications. Developed originally for the Office of Naval Research, the collapsible Inflatoplane was initially designed for the recovery of pilots downed behind enemy lines. Requirements called for a monoplane of minimum weight, simple to fly, and of minimum package size. Attempting to rescue the pilot by helicopter would mean exposing its crews to possibly heavy ground fire. The packaged Inflatoplane, however, could be dropped from the wing rack or cargo hatch of a less vulnerable carrier.

Goodyear embarked on the Inflatoplane program with its single-place GA-447, followed this with its two-place GA-466 for the Army, and is now completing requirements of an Army-Navy contract to deliver ten GA-468s, refined versions of its first one-place model.

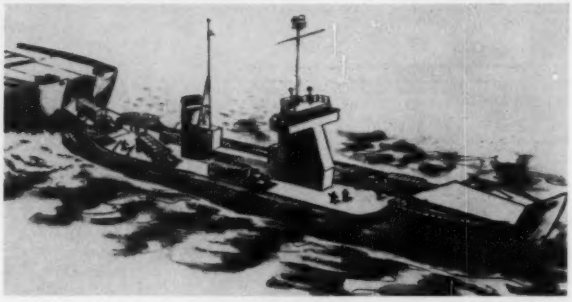
The company's engineers suggest diverse military applications for the high-winged craft. In aerial route reconnaisance, a convoy could carry its own packaged airplanes and send them aloft when needed to scout ahead of the party, as for example, when approaching bends in their route. Other possible uses include stowage aboard a submarine and as a drone, to be sent aloft by a truck-mounted launcher.

Commercial prospects are equally bright. The one-place model, for example, can be fitted into the rear of a station wagon and used by sportsmen, who choose to fish from one lake to another. It would be suitable also for general survey work. The Inflatoplane, according to Schmitz, overcomes the factors that seriously restrict civilian aviation activities, including hangar fees, time spent traveling to the airport, and inevitable delays there. Insurance, he points out, will be lower than for similar light planes because the Inflatoplane lands at low speeds, carries its own housing and can, in an emergency, land on a 300-ft strip of fairly rough terrain.



Army Ship Loads at Sea

A 338-ft shallow-draft cargo vessel built for the Army is designed to take aboard tanks, trucks, trailers, and other vehicles at sea and land them on enemy beaches. Designated BDL (Beach Discharge Lighter) and named Lt. Colonel John U. D. Page, the ship is 65 ft wide and can discharge cargo in depths as shallow as 4 ft. It has a seagoing displacement of 4126 tons, reduced to 2340 tons for landing operations, and is powered by two 110-hp diesel engines. During vehicle transfer at sea, hydraulically-tensioned cables hold the BDL in a stern-to-stern position with another ship. Vehicles are driven aboard over special stern ramps. Builder of the vessel: National Steel and Shipbuilding Inc.



Hydrogen Embrittlement Gets Closer Study

Lab Wants Facts on Mysterious Metal Malady

CLEVELAND—Although not as notorious as oxygen, hydrogen in its own subtle way is a destructive enemy of metal. To pinpoint the role of hydrogen in causing metals to crack is a major item in a research program under way at the Department of Metallurgical Engineering, Case School of Applied Science, Cleveland. Early findings have explained old phenomena, uncovered new facts.

Hydrogen's action on steel is a prime example of the baffling behavior that led to the present study. Hydrogen may be found in solid solution, or in voids on the lattice structure in steel. It is sometimes the result of the decomposition of water in the steelmaking process, or may be introduced by caustic or acid cleaning, welding, plating, or heat treatment. Very small amounts of hydrogen can be deleterious.

For example, high-strength steels can be designed to withstand stresses of 225,000 psi or more. Yet when exposed to much smaller loads, cadmium-plated specimens are often liable to mysterious failures. In retest, however, the fractured parts show their original high strength. Hydrogen trapped by the cadmium plate is the culprit. Case metallurgists have worked out a solution to this problem: A thin cadmium plate is applied, after which the part is baked to drive out residual hydrogen, and plating is resumed up to any wanted level.

"Flaking" (development of small cracks in large steel sections leading to internal failures), the occasional splitting of plates on ships in Arctic waters, and the fracture of cadmium-plated landing gear on planes standing idle on the field, have all been traced to hydrogen embrittlement. Hydrogen also attacks such nonferrous metals as titanium, causing failure of commercial titanium alloys now in use.

Wind-Chill Chart

Actual Temp (F) — Read →					Equivalent Temp With no Wind
82	81	80.5	79.5	76	60
72	71	69.5	67	60	23
63	61	59	55	45.5	-11
51	49	47	42.5	28	-27
41	39	36	30.5	11	-38
30	28	25	18	-5	-40*
20	18	14	6	-19	-40*
10	7.5	3	-6	-35	-40*
0	-2.5	-8	-18	-40*	-40*
45	35	25	15	5	
Wind velocity (mph)					

*Below – 40 F

It's not heat or humidity, but windchill that causes most Army casualties due to weather. Accordingly, human factors specialists in the Army's Surgeon General Office recently published a wind-chill table containing data pertinent to the design of cold-weather clothing and equipment. As the chart shows, wind has a drastic effect on temperature, relative to human comfort. For example, if temperature is 36 F and wind velocity is 25 mph, the effect on exposed flesh is equivalent to −38 F with no wind.

The Panelbuilder

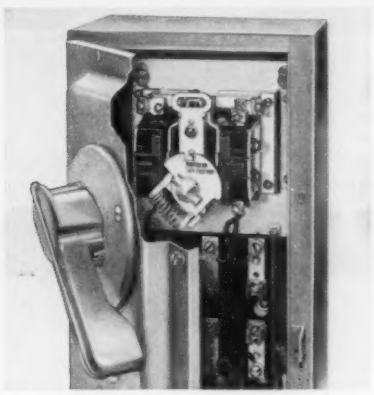
68 YEARS OF SERVICE
CUTLER-HAMMER CONTROL C-H

News for and about Panelbuilders

Cutler-Hammer Inc., Milwaukee, Wis. *Division:* Airborne Instruments Laboratory. *Foreign:* Cutler-Hammer International, C. A.
Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation, Inc.

CUTLER-HAMMER MOTOR DISCONNECT SWITCH SIMPLIFIES PANEL ASSEMBLY

Panelbuilders using the Cutler-Hammer 10904 Motor Disconnect Switch report it provides important savings in time and effort in the assembly of their control panels. The complete unit consists



7/16" radial adjustment of the cover mounted mechanism assures correct alignment with panel mounted disconnect switch.

of a contactor type disconnect switch mechanism, adjustable operating shaft, cover interlock, and external operating mechanism. The switch mechanism uses the same basic structure of the famous Cutler-Hammer Three-Star Contactor, and is easily panel mounted and wired. To mount the external operating handle mechanism, five holes are drilled in the cover following template directions provided with each unit. Exact alignment of these mounting holes with respect to the switch mechanism isn't critical. Compensation for misalignment is provided through the operating handle mechanism's 7/16" radial adjustment. The Cutler-Hammer 10904 Motor Disconnect Switch can be used in any enclosure where the panel-to-cover depth is between 5¾" and 20¾". External operating mechanisms are also available for type F, G, J, K, KL, and L circuit breakers. For further information write for Bulletin 10904- X243. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

CONTROL PANEL CORPORATION SUPPLIES HYDRAULIC PRESSURE GENERATOR CONTROL

One of thirty hydraulic pressure control units supplied by the Control Panel Corporation equipped with Cutler-Hammer Components.

During the past five months the Control Panel Corporation of Chicago, Illinois, has supplied a large number of these compact, NEMA 12 enclosed hydraulic pressure generator control units. The control units are used in conjunction with high speed riveting on a mass production assembly line. Typical of the control equipment used on high volume production machinery, every effort was made in the choice of the components to insure dependable, trouble-free operation.

Mr. H. A. Hart, President of the Control Panel Corporation, reports: "It has been our experience the proper performance of any machine powered by electric motors depends directly upon the control equipment used . . . no machine can be more dependable than the

Mr. H. A. Hart

control which directs and protects it. This is why we and many of our customers consider a component's record of performance an important factor when selecting the components to be used in the controls we supply."

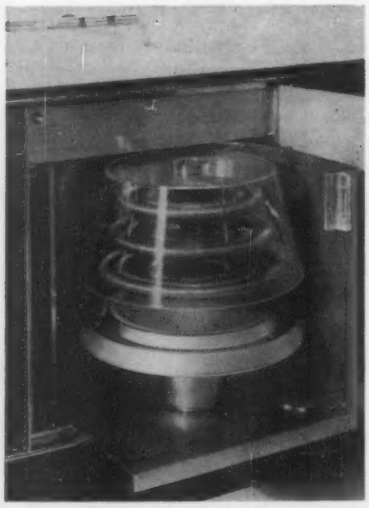
PANEL BUILDERS HANDBOOK SIMPLIFIES SELECTION OF ELECTRICAL COMPONENTS

This handy 70 page reference guide is specifically edited to assist design engineers and control panelbuilders in the selection of electrical control components and control accessories. Every effort was made to make this book as concise as possible, and yet it includes such vital information as wiring diagrams, dimension drawings, ratings, ordering information, and a maintained price list. Address your request for your personal copy of Bul. EE120- X243 on your company letterhead. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

Portaburner is one of many portable, plug-in gas appliances used in Whirlpool's new gas kitchen. Burner is a disc of porous silicon carbide which heats to incandescence. Pyroceram feet hold cooking utensil at the proper distance from the burner. One of two outlets shown is for gas, the other for electricity which is used for ignition in place of a pilot light.

Space-age materials and a hot new burner are design keynotes in an idea kitchen featuring

Plug-In



Hot water is produced at high efficiency by the new power burner. Since water is heated almost instantaneously, no tank is needed.

What does the other kind of appliance have that the gas appliance lacks? Starting from this point, engineers at Whirlpool Corp. and industrial designers at Sundberg-Ferar Inc. pooled ideas to come up with the prototype of a new gas kitchen. Complete with Pyroceram heating surfaces and silicon-carbide burners, the futuristic appliances are a startling departure from the old stationary gas stove—all units, small and large, are plugged into gas outlets in the walls and floor when needed.

Appliances in the new kitchen are designed around Whirlpool's "power-burner" concept. Fuel and air are premixed in proper proportions and burned in porous silicon-carbide burners. The burner heats to incandescence with little or no flame on its surface, and since no secondary air is needed, combustion can take place in a covered space. Efficiency of the power burner is claimed to be more than double that of conventional gas burners—83 per cent vs. about 40 per cent. All burners are self-energizing—by electricity—which eliminates the conventional pilot light.

Portability isn't the sole feature of the new gas kitchen. Engineers and industrial designers added many refinements to each kitchen unit as they went along. A push-button sink permits the housewife to select water at several preset temperatures, and the faucet retracts flush with the sink when not in use. A mobile, self-propelled servacart contains dishwasher, toaster, and food-warming compartments, and wall shelves move up and down on tracks.

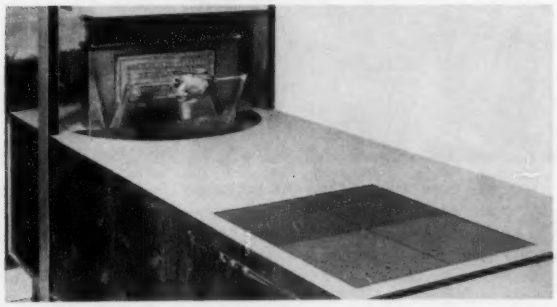
As a finishing touch, designers of the new kitchen are busily work-

Pyroceram plug-in utensils are virtually indestructible, wipe clean with a damp cloth. Plug-in utensils similar to these units, but not gas-fired, are on the market now.

GAS APPLIANCES

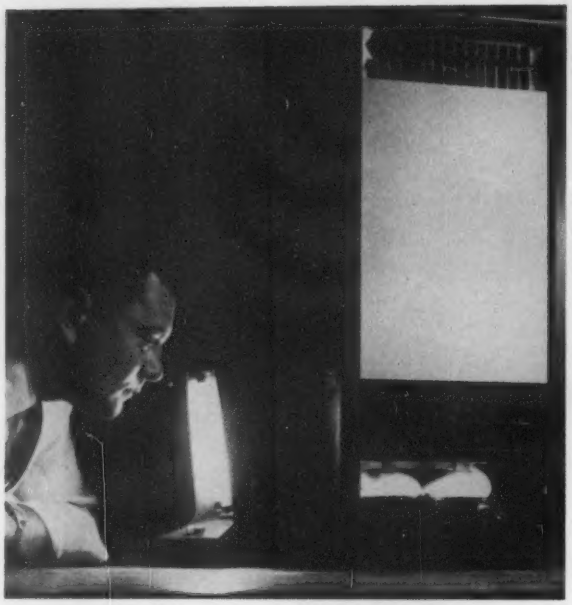
ing on a compact, gas-powered generator that will supply small quantities of electricity—just enough power to energize the various appliances and make the kitchen completely gas dependent.

Not all of the appliances will be available in the immediate future, but Whirlpool says it will produce a gas stove early next year that incorporates the silicon-carbide burner and Pyroceram heating surfaces.



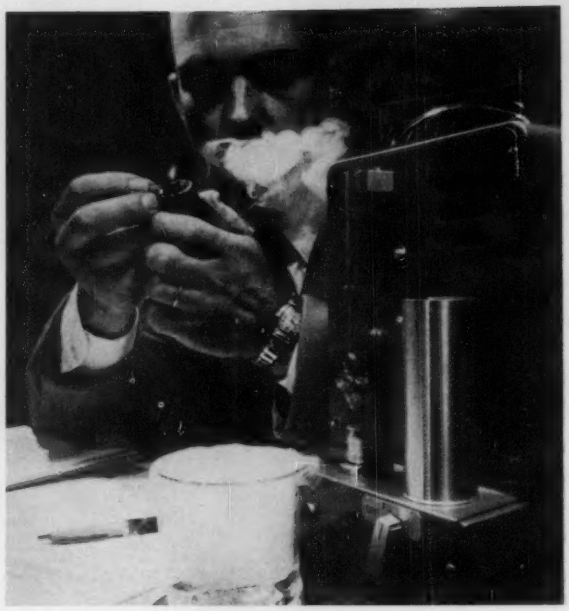
Burners are hidden under a thin sheet of Pyroceram, permitting this countertop range to double as a grille. Developed originally for missiles, Pyroceram is well-suited for kitchen applications—it can withstand 3500-F temperatures, is extremely durable, and exceptionally easy to keep clean. Rotisserie, left, is swivel mounted and has an exposed silicon-carbide burner that produces infrared heat.

High-efficiency of the power-burner has prompted Whirlpool engineers to predict a complete "gas center" housed in a kitchen cabinet. The one unit would heat and cool the entire house, purify the air, and provide refrigeration for the kitchen's several food-preservation lockers. Ultimate aim is to include a gas-powered generator to supply electricity used in energizing various gas appliances.



More on Thermoelectricity: Efficiency's Up

Ten watts of electric power are produced directly from heat without mechanical conversion of any kind in this experimental thermoelectric generator that has powered a public address system. Efficiency of this model is about 10 per cent; researchers aim for an eventual 30 per cent efficiency. Practical applications for the thermoelectric process, which works best around 2000 F, will include direct conversion of atomic energy and, in moon installations, solar energy. Developer is Westinghouse Electric Corp.



Detector Ignores False Alarms

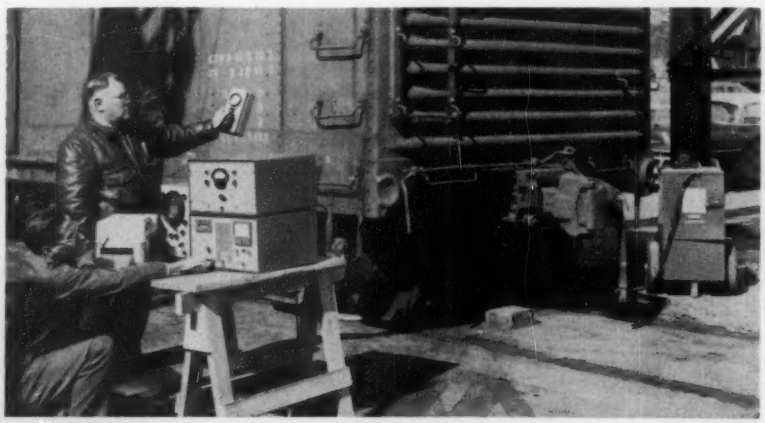
Explosive vapors, fire, or smoke can be detected individually or simultaneously by an ultraviolet-sensitive tube about the size of a man's finger. The highly selective tube is designed to ignore ultraviolet light from other sources, so false alarms are unlikely. It is relatively unaffected by random radiation and maintains a fairly consistent operating level. Developers claim it has a nearly unlimited life expectancy. Manufacturer is the Minneapolis-Honeywell Regulator Co., Minneapolis.

Gamma Rays Weigh Speeding Box Cars

Atomic Source Furnishes Instantaneous Reading

CLEVELAND—Scanning a loaded box car moving at 30 mph, New York Central's experimental atomic weight recorder shows the weight of car contents within ±1.0 per cent. Developers aim for ±0.2 per cent, which is accurate enough for billing purposes.

Radiation for the prototype scanner comes from a small cobalt-60 source contained in a lead box between the rails. Although strong enough to penetrate a freight car's maximum allowable load, rays do not affect sensitive shipments like photographic film, nor are they harmful to humans, say railroad spokesmen. Just to be on the safe side, the cobalt source is automatically shielded unless a freight car passes over it at a speed faster than 5 mph.



Experimental box-car weight computer interprets variation in radiation from cobalt-60 source (box between rails) as weight of car passing over it. Weight is a direct function of radiation absorbed by the load. The unit shown is said to be accurate to within 1.0 per cent.

In actual practice, the source spans the width of the rails under the car, giving an evenly distributed field of gamma rays across the tracks. Over the car, an extended detector will record the radiation that passed through the car and actuate a computer which will translate the absorbed radiation into car weight.

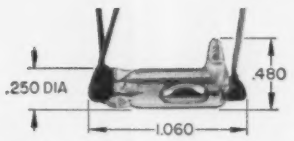
Costing about one-fourth the price of conventional electronic scales, the new device permits weighing without uncoupling. When used

MICRO SWITCH Precision Switches

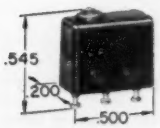
Five switches of special interest to Electronic Engineers Three of them are NEW

NEW

ultra-small super-sensitive mercury switch AS603A1



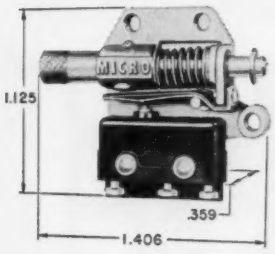
This new switch, designed for vertical gyros, stable platforms, missiles and rockets, is the most precise mercury switch available. Differential angle—.150° max. Mass shift—.085 gm. cm. SPDT. It operates reliably at temperatures as low as –65° F. Hermetically sealed contacts. Switch is unaffected by water vapor, dust, dirt, fungus and corrosive fumes. It is rated at .225 amps., 30 vac, 400 cps resistive load. Weight—3.5 grams (including leads). Ask for data sheet No. 153.



NEW

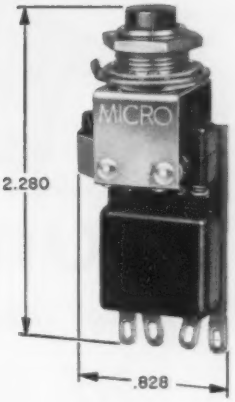
"SX" series sub-subminiature switches

These all-new switches combine extremely small size with "regular size" electrical capacity and excellent reliability. They present a new set of possibilities to the designer of compact devices. 5 amps. 250 vac, 30 vdc. Two mounting holes accept No. 2 screws. Weight—1/28 oz. Ask for data sheet No. 148.



Subminiature door interlock switch 7AC1-T

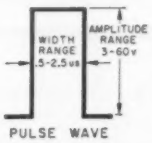
Cuts off power in equipment cabinets when service door is opened. Manually pulling the rod actuator to maintained contact position closes circuit for checking. When door is next closed, switch returns to normal . . . re-sets itself to safety position. Ask for data sheet No. 108.



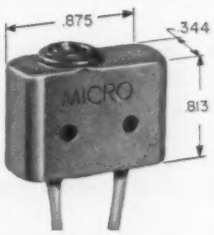
NEW

"1PB600" series "One Shot" switches

These new switch assemblies produce a one-and-only-one pulse output. Miniature package includes push-button switch and potted one-shot circuit. Eliminates need for designing special pulse input circuits for high speed electronic devices. The square wave pulse width is factory adjustable from .5 to 2.5 micro seconds, and the amplitude from 3 to 60 volts. Both width and amplitude are independent of speed of operation of switch. Ask for data sheet No. 150.



"SE" series environment-free subminiature switches



"SE" Series switches are the smallest and lightest environment-free switches available. Construction is completely sealed. Operate reliably from −65° to +350°F. Pin plunger actuation. Choice of contact arrangements. Rating 5 amps. 125 or 250 vac. 28 vdc—15 amps. inrush; 4 amps. resistive; 3 amps. inductive. Weight—.24 oz. (without leads). Ask for Catalog 77.

Engineering assistance in switch applications is available from the MICRO SWITCH *branch office near you. Consult the yellow pages of your telephone book.*

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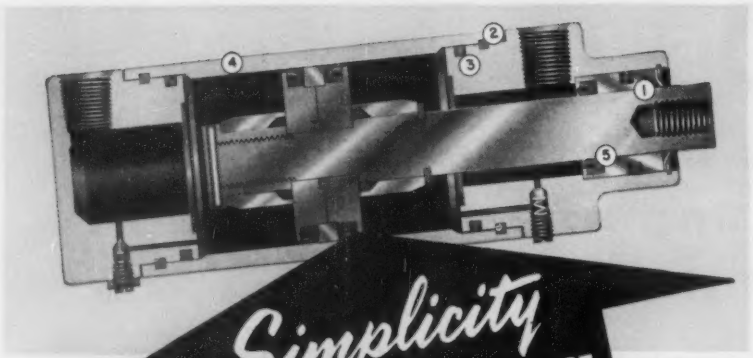

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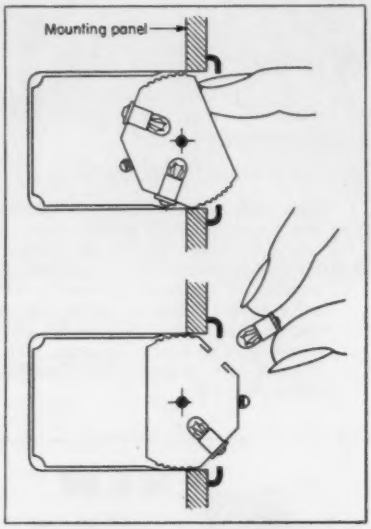
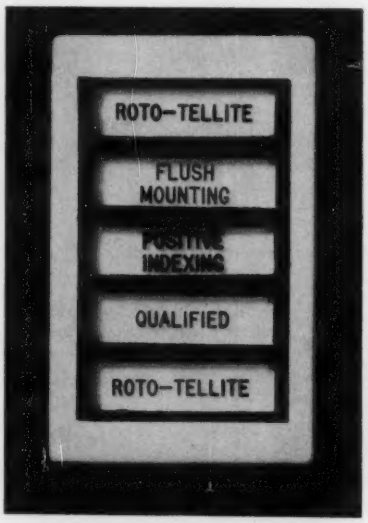
with suitable computers at strategic locations, it can summarize a train's tonnage quickly and accurately, thus affording close control of weight to traction-power ratio.

The development is a product of the new research laboratory opened by New York Central Railroads in Cleveland.



Turret Rotates, Reveals Lamps

A rotatable lamp turret, holding lamps in a panel-mounted "word" indicator, permits replacement of burned-out bulbs from the front of the panel. Lamp capsules are molded high-temperature nylon. Individual turret units can be stacked either vertically (below) or horizontally. Called Roto-Tellite, the indicator is a product of Master Specialties Co., Los Angeles.



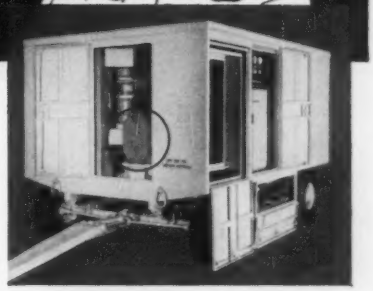
Vanadium Milestone

A big step in development of low-carbon ferrochrome alloys was chalked up recently with production of an 89-lb, high-purity vanadium ingot. The melt was accomplished by General Electric's Industrial Heating Dept. for Vanadium Corp., and is said to be the largest vanadium ingot ever produced. Rolled, drawn, and extruded products of the ductile metal are finding new uses in aircraft, missiles, nuclear reactors, and electronics equipment.

Aluminum Foil Replaces Wire In Big Power Transformer

A 20,000-kva power transformer being built by General Electric will have aluminum foil windings and aluminum core clamps, tank, and cooling radiators. The transformer is believed to be the largest ever built with all electrical and structural parts made of aluminum. The unit will be used in a substation at Aluminum Co. of America's Massena, N. Y. Works where it will step down 115,000-v power to 13,800 and 6900 v.

Use of aluminum foil instead of copper wire for windings gives better transient-voltage characteristics, reduced space factor, and lower heat loss, according to GE engineers. These, rather than weight reduction, are the chief advantages, although aluminum in tank and structural parts reduces over-all weight.



Hussman Air Conditioners Incorporate M-D Blowers for Dependable Performance

Utilizing low-cost, light-weight M-D 3-Lobe Rotary Positive Blowers specifically designed for ground support equipment, Hussman Aircraft Div., St. Louis, build mobile air conditioners for Convair's new B-58 Delta-wing bomber. Hussman's MA3 unit furnishes 100#/min. of 45° air at 3½ psig thru an 8″ flexible duct for cooling the complex instrumentation and guidance systems on the B-58.

M-D's new model M100, smaller, lighter, lower in cost than any other blower, can deliver a minimum of *100#/min. (1333 scfm) up to 8 psig*, and meets all government-specified altitude and temperature conditions. The M-100 is ordinarily run at 3450 rpm with either electric or gas engine drive.

You can rely on the M-D Blowers for dependable performance . . . years of experience assure high quality 3-Lobe Rotary Positive Blowers for—*Jet Starters, Cabin Leakage Testers, Air Conditioning Units.*

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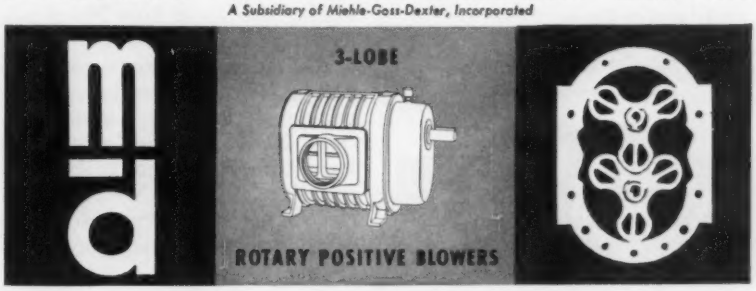
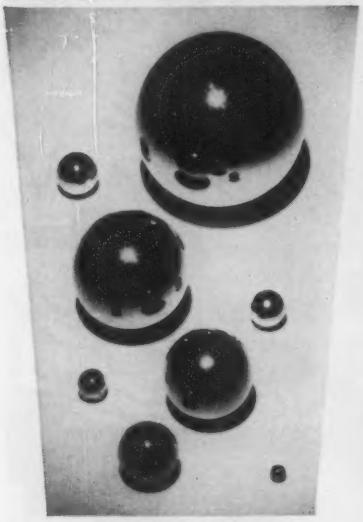


Circle 417 on Page 19

HARD SMOOTH AND ACCURATE



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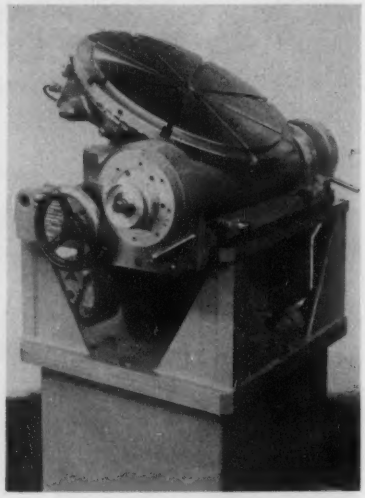
3676 Jackson Road, Ann Arbor, Michigan

Circle 418 on Page 19



Earthbound Space Platform

Simulation of a stationary space platform is the job of this rotary table used to calibrate and test navigational gyroscopes. The table makes one revolution in 23 hr, 56 min, and 4.09 sec—the sidereal day. It rotates at a angle correlated to a selected star's path, and opposite to earth's rotation. A special rim mounted on the table face has lugs spaced 5 deg apart. As the table rotates, a sensing head picks up the magnetic center of each lug and passes an output signal to the calibrating equipment. Plus and minus tolerances for various degree points—from 15 to 25,000 deg per sidereal hr—are held to a fraction of 1 per cent. Pratt & Whitney designed and built the machine.

Army Messages, 6 ft per min

Capable of printing 3000 words per min — a 1-min message, 6-ft long, is shown here—the Army's new teletypewriter will join the world's fastest known military teletype network. Operating at just 750 words per min to meet Army Signal Corps requirements, the new machine uses no ordinary keys. Letters are shot at the paper electronically by a bank of electrode guns. Each gun aims at a corresponding spot on the paper and can fire any number or letter. After the volley of letters, each line of type passes rapidly over powdered ink and a heated roller and appears an instant later as clear, readable text. Developed by Army Signal R & D Lab. and Burroughs Corp., the machine operates from code tape or can be plugged into long-distance radio or telephone circuits. It's also used as a computer readout.

Battles Raging Every Day On Navy Warfare Simulator

Huge Electronic Installation Cuts War-Game Cost

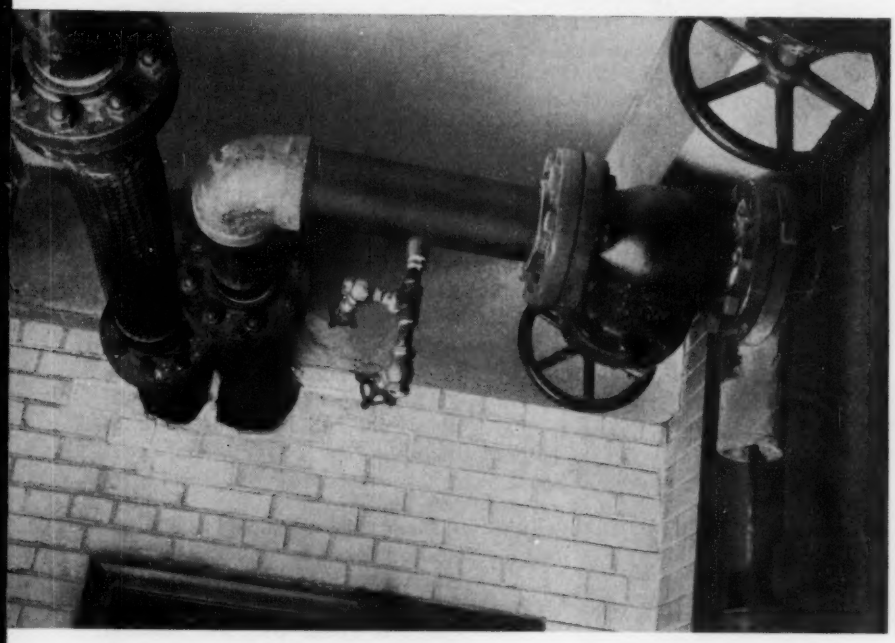
Combat command decisions controlling the fate of huge Naval task forces are made with a high degree of realism on the Navy's new Electronic Warfare Simulator. The complex electronic installation, called NEWS, is housed in a block-long, three-story-high building at the War College in Newport, R. I. NEWS not only serves as an excellent training facility for Naval officers, but provides a much needed tool to explore and evaluate the effectiveness of new tactics and concepts in naval warfare. It also reduces the need for mock fleet exercises, and the tremendous expense associated with real fleet maneuvers.

The physical plant of NEWS consists of equipment rooms, control rooms, an umpire area, and a series of command centers.

Umpires are located in an auditorium physically separated from the command centers. Each is an officer with wide professional ex-

APPLICATION HINTS:

Ways to simplify construction and cut costs with Flexpipe



Flexpipe helps meet tough piping problem in air conditioning an existing building

THE PROBLEM: Air conditioning an existing office building usually calls for a bit of ingenuity in design. One large New York office building decided to air condition by making provision for packaged, water-cooled units to be installed on any floor as tenants required.

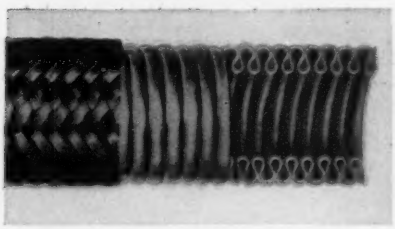
This called for four 10-inch risers, running the height of the building, to carry cooling water between the cooling tower and the branch pipes at each floor level. Because of structural conditions, the risers could not be run down through the basements and supported from below. The combined weight of pipes and the water was so great that they could not be anchored at any one point on the structure.

So the consulting engineers, Zimmermann Engineering, New York, floated the risers on spring hangers, distributing the weight evenly over all floors. This meant, however, that the risers were free to move. A riser full of water weighs several tons more than an empty one and settles about two inches.

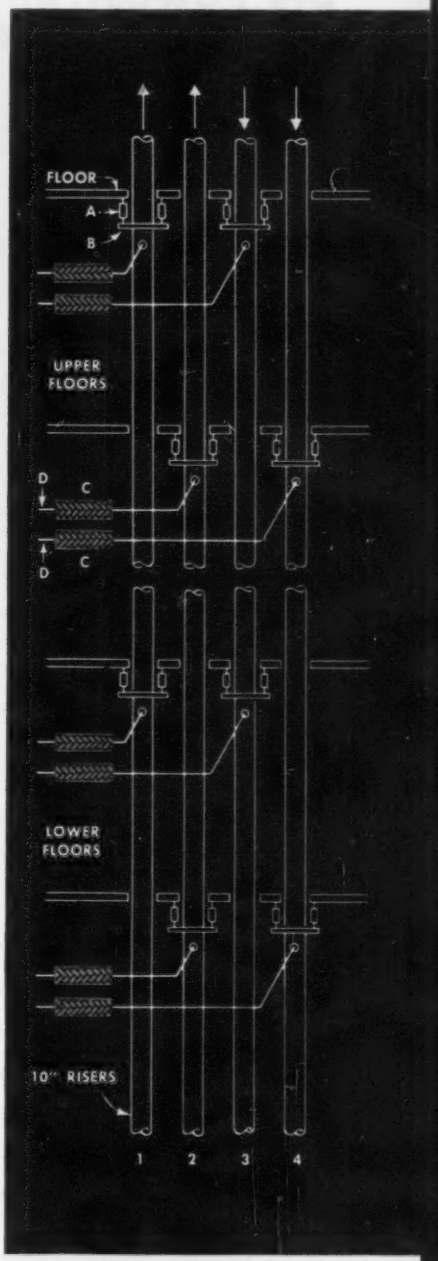
Therefore connections between risers and branch pipes had to be flexible. They also had to have strength, because water pressure at the lower floors approaches 400 psi.

THE SOLUTION: Flexpipe connectors were the answer. They provided the flexibility and the strength required. Furthermore, they were available in the sizes needed —from 5" diameter at the lower floors to 2" at the top floors.

WHERE TO BUY: Flexpipe connectors come in convenient standard sizes and are sold by leading distributors. They can show you samples and answer questions about service applications. For the name and address of the one serving your area, or for more detailed information, write to: The American Brass Company, American Metal Hose Division, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ont. 58226



FLEXPIPE'S flexible core can be either tin bronze, hot dipped galvanized steel or stainless steel. End fittings (attached): flanges, threaded males and welding nipples.



SCHEMATIC DIAGRAM showing how cooling-water risers were installed. A: spring hangers. B: pipe clamps. C: Flexpipes. D: branch pipes at each floor. 1, 2, 3, and 4: risers, 10 inches in diameter. *Upper left:* Photo of Flexpipe installation at a lower floor.

Flexpipe® an ANACONDA® product

made by The American Metal Hose Division of The American Brass Company

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SPECTROL PRECISION MECHANISMS

Black Boxes, Dry Powder, and Missile Making

It takes a lot of black boxes plus a good bit of dry powder to launch an occasional missile down at Cape Canaveral. Some of the black boxes contain Spectrol precision mechanisms, inline or otherwise, designed to control critical flight functions.

You may be interested in one of these units that we recently delivered to the missile people which has a number of industrial control applications outside this rather esoteric field. Known as a Function Programmer, this particular 3 x 4 x 5 inch package is used for the flight control of guided missiles. Inside the Spectrol black box is a precision mechanism consisting essentially of a permanent magnet dc motor which drives a Spectrol precision potentiometer and six rotary switches of special design developed by Spectrol. These units are interconnected by an appropriate gear train. In operation, the precise opening and closing of the rotary switches and the rotation of the Spectrol precision potentiometer control the flight altitude of the missile with respect to time.

As you can well imagine, devices of this type must be built to operate within precise specifications under severe environmental conditions. In addition to the usual MIL specs, this unit was built to withstand a 2000 cps vibration at 10 G's and a shock of 50 G's. The Spectrol precision mechanism not only operates after experiencing these conditions, but during them. Overall program timing accuracy is 3 percent.

Other applications for this little Spectrol package include checking a number functions sequentially in ground support equipment, programming machine tools, and controlling the order of operation in chemical and processing plants.

To accommodate the numerous countdowns involved in missile testing, this Spectrol precision mechanism runs twice as fast in the "reset" position as the "program" position.

More information, including a helpful 8 page booklet, on this and other Spectrol precision mechanisms designed for use as functional sub-assemblies is yours for the asking. Simply call your nearest Spectrol sales engineering representative or address Department 5711.

SPECTROL

ELECTRONICS CORPORATION

Sales engineering representatives in principal cities.

1704 S. DEL MAR AVE., SAN GABRIEL, CALIFORNIA

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perience in the type of operation he umpires.

Images of each simulated force are portrayed on a 15-ft master-plot screen. NEWS provides extensive communications systems, as well as force radar presentations. It indicates course, speed, and in the case of aircraft or missiles, altitude of the various elements.

Commanders, their staffs, and individual unit officers are located in the various command centers where they can observe and evaluate the battle as it develops. Commanders exercise control of forces and test the soundness of plans exactly as they would under combat conditions.

Rapid calculation of the results of all interactions enables the battle to progress at any rate of speed. The action can also be held up at any point to permit detailed analysis of impending victory or defeat.

Meetings

AND EXPOSITIONS

Jan. 12-14—

Fifth National Symposium on Reliability and Quality Control in Electronics to be held at the Bellevue-Stratford Hotel, Philadelphia. Sponsors are American Institute of Electrical Engineers, American Society for Quality Control, Electronic Industries Association, and Institute of Radio Engineers. Additional information can be obtained from E. K. Morse, Aeronautical Radio Inc., 1700 K St. N.W., Washington, D. C.

Jan. 21-23—

Southwest Electronic Exhibit to be held at the Arizona State Fairgrounds, Phoenix, Ariz. Further information is available from exhibit headquarters, 4353 West Missouri, Glendale, Ariz.

Jan. 26-27—

American Society of Lubrication Engineers. First Annual Gear Symposium to be held at the Morrison Hotel, Chicago. Further information can be obtained from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

Jan. 26-29—

Fourteenth International Heating & Air Conditioning Exposition to be held at Convention Hall, Philadelphia, under the auspices of the American Society of Heating and Air-Conditioning Engineers. The society's 64th annual meeting will be held concurrently. Further information can be obtained from exposition headquarters, 480 Lexington Ave., New York 17, N. Y.

Jan. 26-29—

Institute of the Aeronautical Sciences. Annual Meeting to be held at the Sheraton-Astor Hotel, New York. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 26-29—

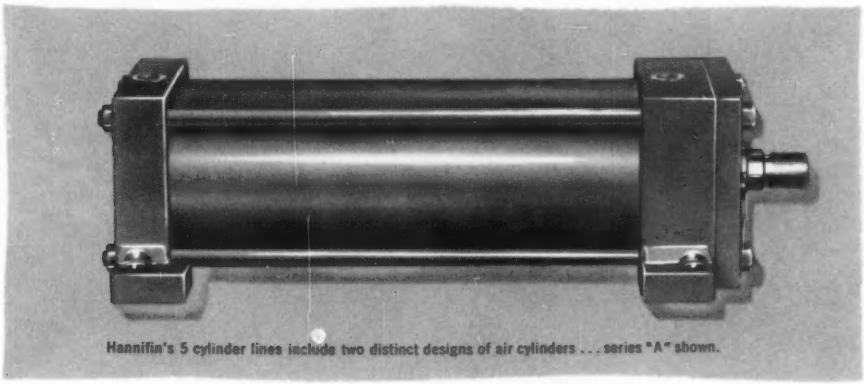
Plant Maintenance and Engineering Show to be held at Public Auditorium, Cleveland. Additional information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Feb. 3-5—

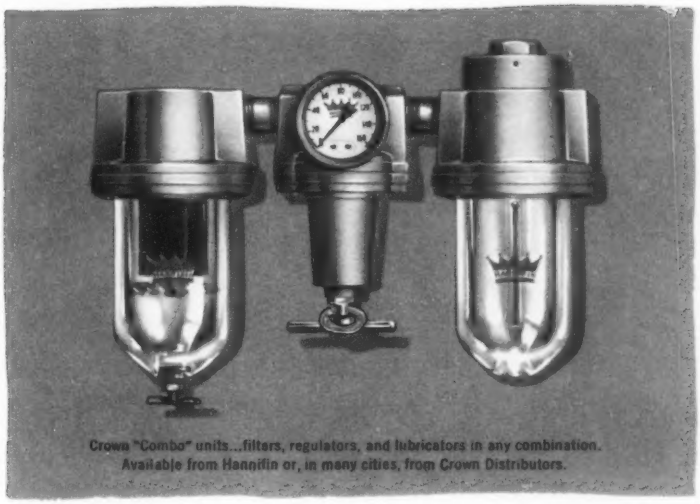
Society of the Plastics Industry Inc. Fourteenth Reinforced Plastics Conference to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from SPI headquarters, 250 Park Ave., New York 17, N. Y.

"The boss wants to see his drawing, and he doesn't want to have to square it up again."

PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

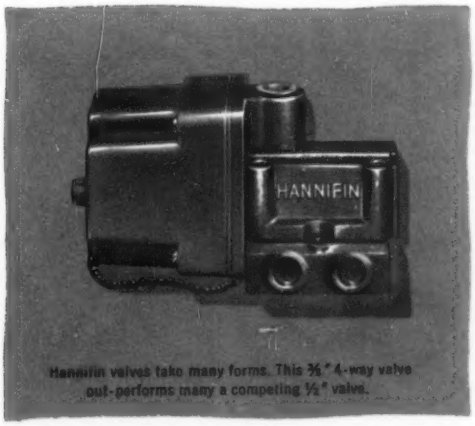


Hannifin's 5 cylinder lines include two distinct designs of air cylinders . . . series "A" shown.



Crown "Combo" units...filters, regulators, and lubricators in any combination. Available from Hannifin or, in many cities, from Crown Distributors.

Only **HANNIFIN** makes all these **AIR POWER COMPONENTS**



Hannifin valves take many forms. This ⅜" 4-way valve out-performs many a competing ½" valve.

Anywhere you use compressed air to do work, Hannifin can help you. Hannifin cylinders for the "muscles". . . Hannifin air valves for any type of actuation, hand, foot, cam, solenoid, or pressure . . . the Hannifin "Crown" Line of filters, regulators, and lubricators for lasting air power efficiency . . . all are built by Hannifin to just one standard, the best.

Turn to Hannifin, too, for expert help in applying air power components. A Hannifin field engineer is as close to you as your telephone, wherever you are. Write us for his address—or, he's listed in the alphabetical section of Thomas Register. It's that easy.

HANNIFIN COMPANY

505 South Wolf Road • Des Plaines, Illinois

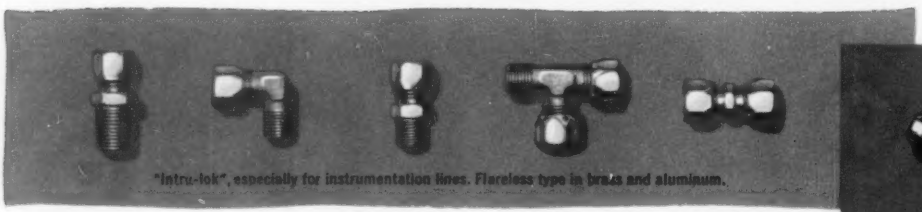
A DIVISION OF PARKER-HANNIFIN CORPORATION

PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

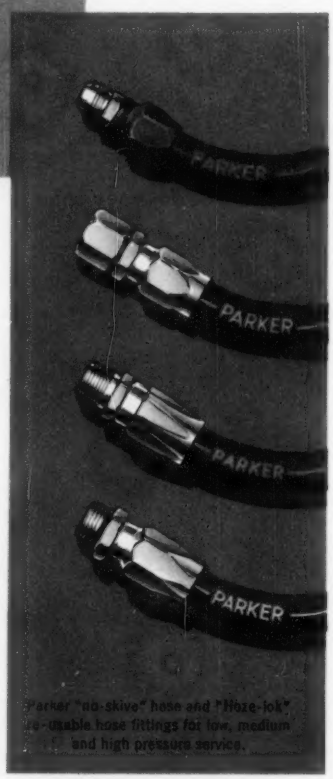
"Triple-lok", the "industrial standard"... in brass, stainless steel, aluminum, and cadmium plated steel. For flared tubing.

"Ferulok"®, the flareless type with the visible "bite", especially for heavy-wall tubing... in steel and stainless steel.

"Weld-lok" socket-type fittings, steel or stainless steel. Also "Braze-lok", in almost any metal.



"Intru-lok", especially for instrumentation lines. Flareless type in brass and aluminum.



"Parker "no-skive" hose and "Hoze-lok" re-usable hose fittings for low, medium and high pressure service.

Only from Parker

such a wide range of fittings...so fast

If it's an industrial fitting, whether for tubing or for hose, Parker has it or can make it, in standard sizes in any metal.

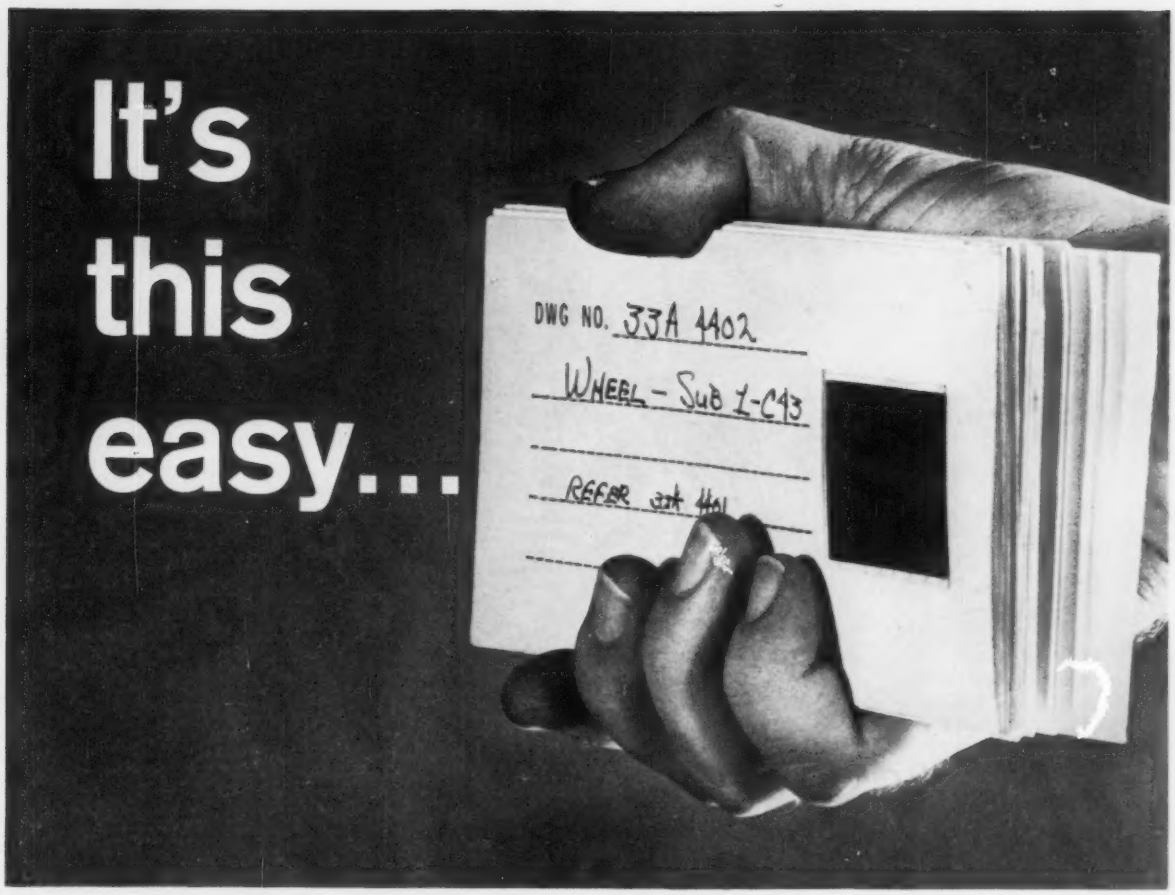
Parker "Triple-lok" for flared tubing . . . Parker "Ferulok"® for heavy-wall tubing . . . Parker "Weld-lok" for high-temperature, high pressure lines. ("Braze-lok", our newest line, does not require an open torch, is for medium temperatures.) "Intru-lok", for copper, aluminum or plastic instrumentation lines, requires no flaring. Parker hose and "Hoze-lok" re-usable hose fittings require no skiving of the hose.

There's a Parker distributor near you, write us for his name . . . call him for Parker catalogs.

Parker Fittings and Hose Division

17325 Euclid Avenue • Cleveland 12, Ohio

A DIVISION OF PARKER-HANNIFIN CORPORATION



to end miles of files

Now... put your engineering drawings on unitized microfilm at new low cost, without capital investment. Tired of groping through crowded, bulky engineering drawing files? You need to no longer! The new Microline® Service Center program helps you streamline your files by converting them to a Microline *card file* system.

With a Microline card file system, all your drawings will be right at your finger tips. You save space, too! Up to 95% of your filing and storage space can be put to more productive use.

And you can gain all these advantages without investing capital! Your local Microline Service Center handles all filming, processing, unitizing, indexing... can make microfilm duplicates or enlargement prints for pennies. Your Service Center will lease you microfilm readers, too, if you wish. Every Service Center is staffed by experts trained to help you set up the unitized card file system best suited to your needs.

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Small firms can enjoy the benefits of a microfilm drawing-control system for the first time. Large companies can experiment without large cash outlays.

So, get *your* print files in hand! Mail the coupon below... today! You'll get the full Microline Service Center Story, the name and address of your local center... and a dramatic demonstration offer at no cost or obligation.

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Microline Products, Ozalid Division of General Aniline & Film Corp.
Microline in Canada, The Hughes-Owens Company, Limited, Montreal.

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JOHNSON CITY, N. Y.

Please send me the name and location of my local Microline Service Center. Also, the booklet giving the complete Microline story and containing a free demonstration offer.

Name _____ (PLEASE PRINT)
Firm _____
Position _____
Address _____
City _____ State _____

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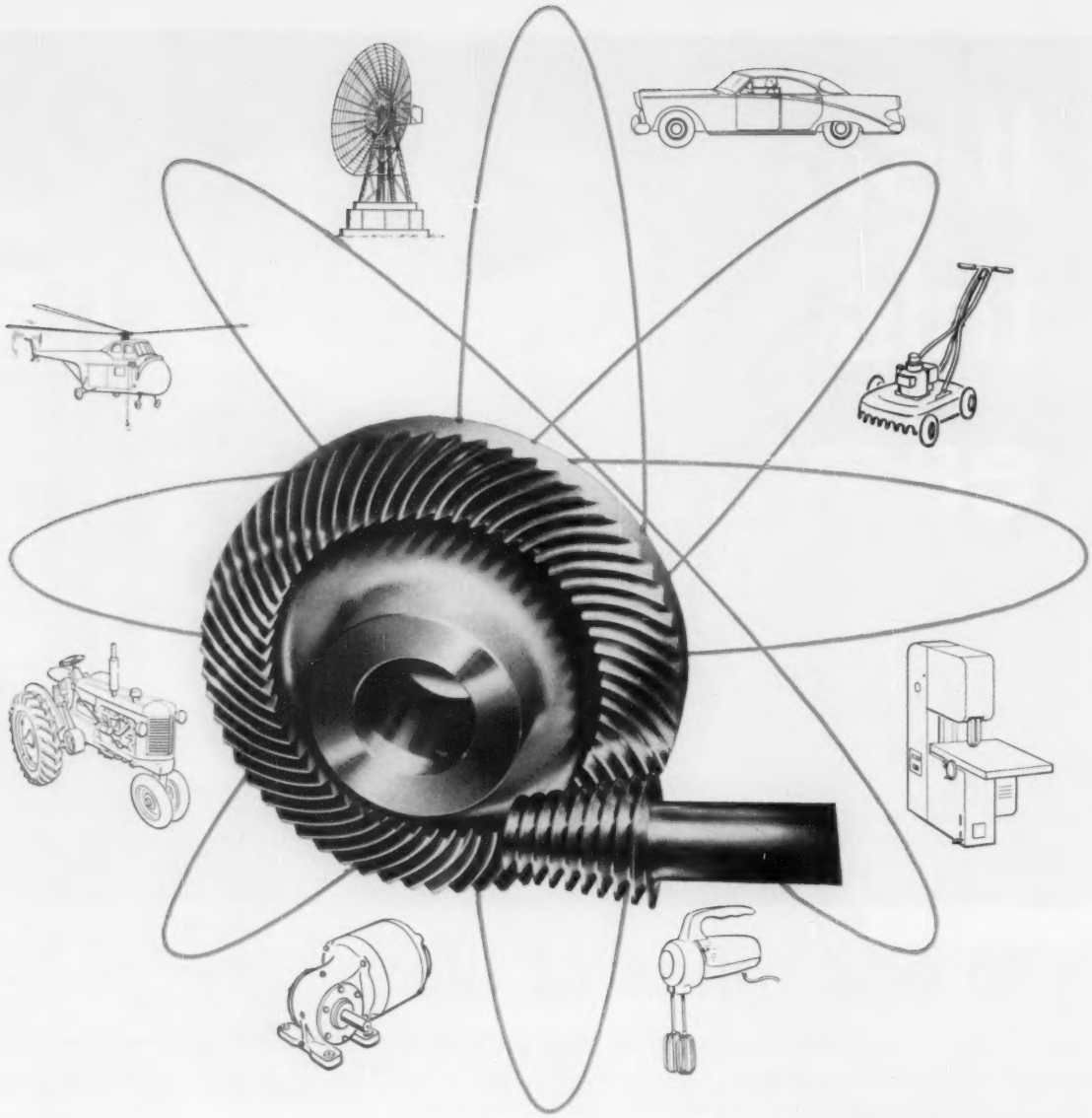
Circle 423 on Page 19

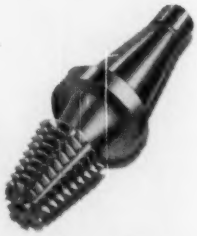


NEW DESIGN HORIZONS
for your product

SPIROID® GEARS SAVE SPACE—SAVE WEIGHT . . . OFFER POSITIVE BACKLASH CONTROL

Spiroid Gears extend the horizon of mechanical frontiers, offer new product design opportunities for increased performance standards. Comparatively smaller, stronger and more efficient, Spiroid Gears provide an entirely new relationship between power transmission and gear size. You get more power from less space, more profit from your product. Spiroid Gears can be produced in standard gear materials in any size and in ratios from 9:1 to 300:1. They are cut on conventional equipment, or can be molded, die-cast or sintered.

Write for informative Spiroid booklet, "More Power, Less Space."



Spiroid® Hobs for producing Spiroid Gears are available only from Illinois Tool Works.

SPIROID GEARS
SPIROID DIVISION OF ILLINOIS TOOL WORKS

2501 N. Keeler Avenue, Chicago 39, Illinois

itw

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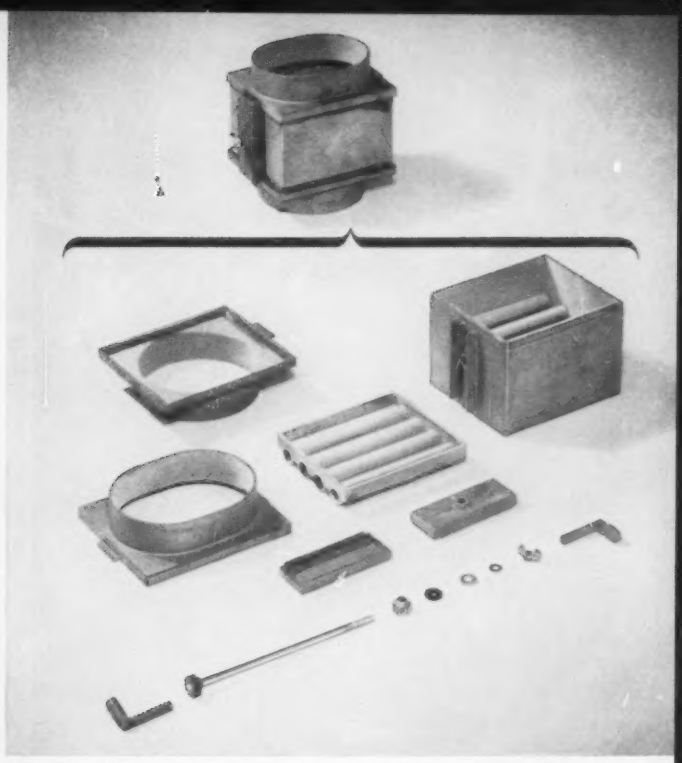
D-J casts, finish machines, plates and assembles door hardware for a Mid-West merchandiser. Eleven zinc parts are die cast . . . then tapped, reamed, faced and plated. Other parts are drawn and stamped as needed. Springs, lock washers, screws, locks and keys are purchased. Finally, D-J assembles and packages the units.

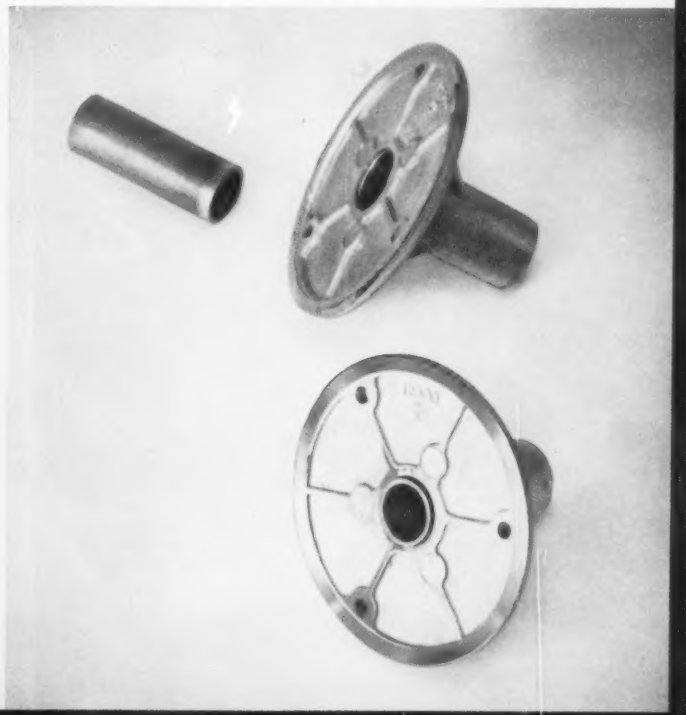


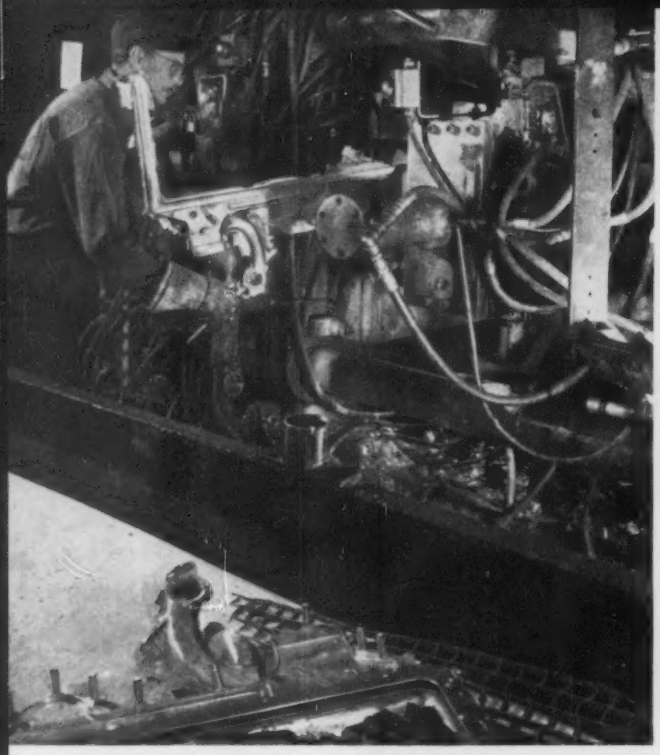
D-J die casts, machines, flock finishes and assembles damper for York Corporation. Unit is a complex high precision assembly of ten die cast parts including racks, pinions, and pistons. D-J flocks interior parts before assembly, seals seams to air-tightness under pressure. Exterior surfaces are carefully alodined.

3 pages of <u>proof</u> Doehler-Jarvis can do more for you than die cast parts...

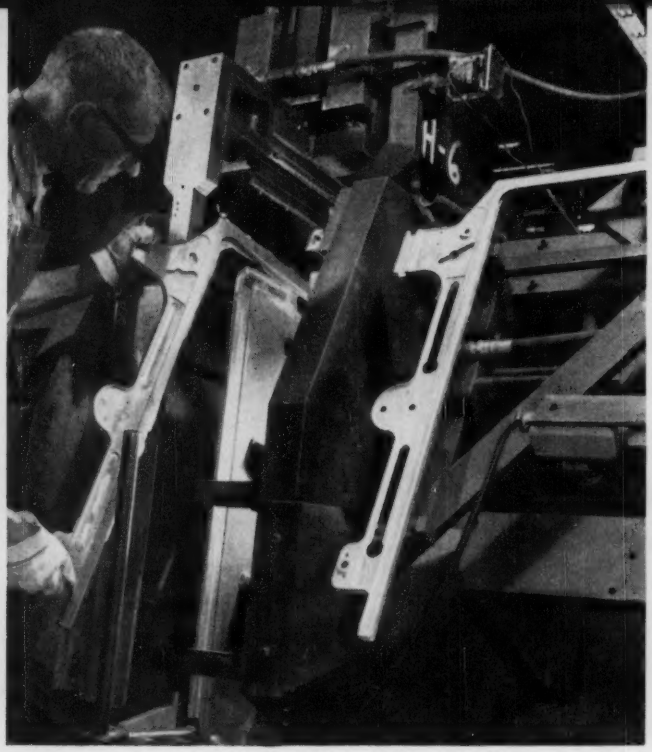
D-J casts, profile shapes, taps and electro-statically paints TV set parts for Radio Corporation of America. Ready-for-assembly die castings are by far the lowest-cost way to produce lightweight metal bezels and glass retainers for RCA Victor TV sets. Their dimensional stability speeds assembly.

D-J casts, machines, and assembles turntable hubs for well-known phonograph manufacturer. Hubs are trimmed, turned, slotted, reamed and fitted with bearings. The bearings are then chamfered and sized. Tolerances of 0.001 inch or less are maintained throughout all these operations.





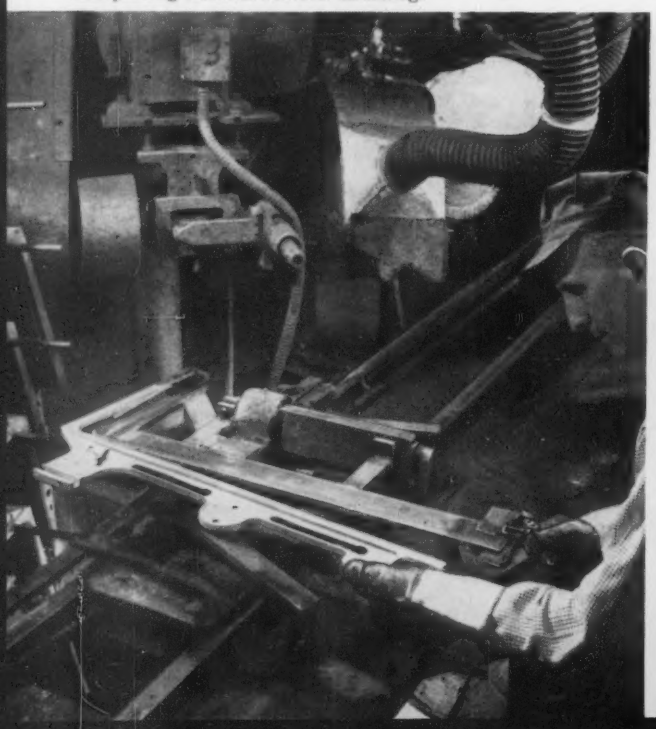
1 **Operator removes die cast zinc main channel** for Lincoln or Continental window assembly from large 48" casting machine. Part is quenched in cooling solution then conveyed to trimming. D-J is now researching production techniques on giant 72" machine, world's largest.



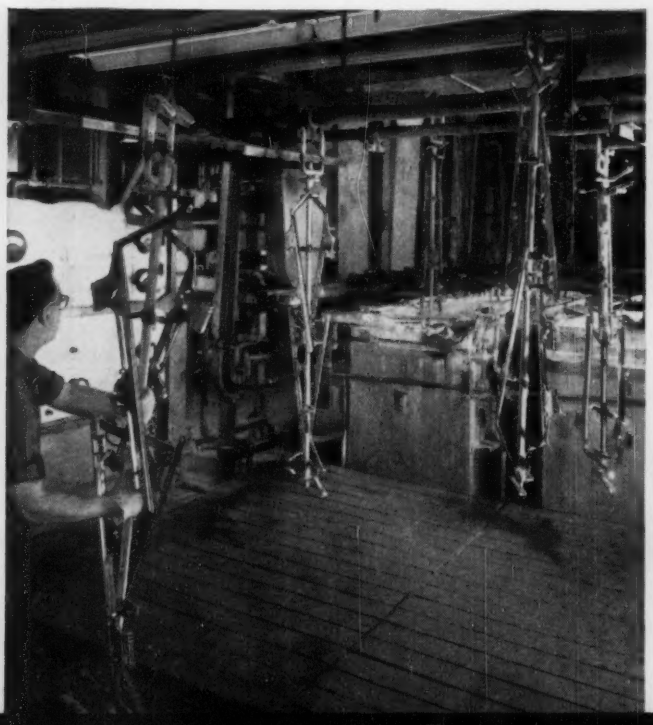
2 **Ingenious double-acting trimmer removes gate,** trims flash, finishes slots, taps 3 holes. Notice jig at right miters corner of frame. Scrap metal is collected, re-melted, re-refined and re-used. Minimum metal consumption is a big advantage of die casting.

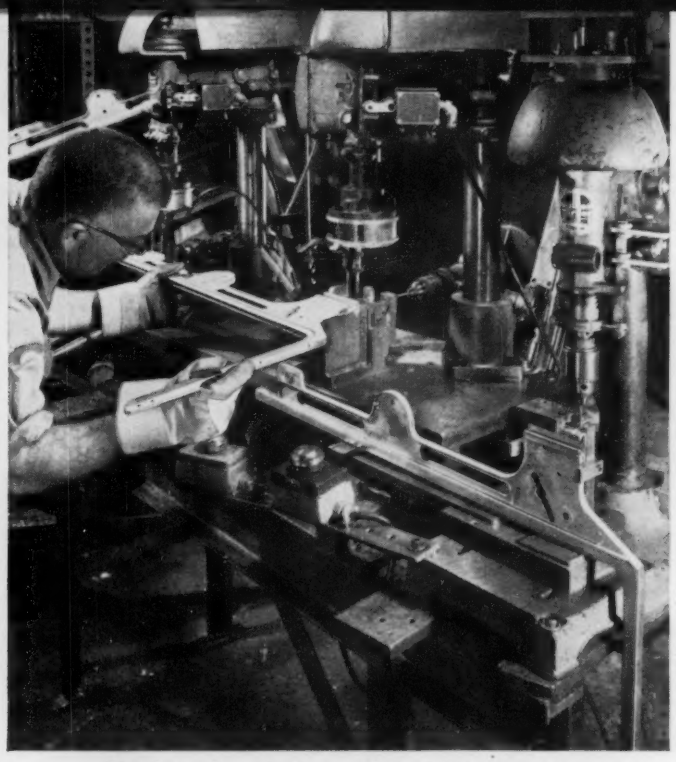
...D-J makes machines, plates, puts together

4 **Buffing, too, is set up for maximum economy.** Part is snap-clamped to device that positions it automatically for buffing wheels. When leaving fast-moving buffing lines, parts are racked and processed by conveyor through degreasing into plating without further handling.



5 **"Christmas trees" carry channels through plating.** Part is given optimum copper, nickel, chrome thicknesses using an automatic "plate-on-plate-off" current sequence that develops unusually high quality long-lasting finish desired for this premium car.





3 **Ganged machines complete drilling, tapping, reaming.** Behind operator you can see a universal work toting device. Removable pins support work and present it to operator prepositioned for speediest handling. (For another view of device, see following picture.)

a window assembly for the Lincoln Continental

6 **Window is glazed and finish assembled in special jig.** Here die cast channel, glass and other parts (some made, some purchased by D-J) are put together and weather sealed. Packaged part is shipped both to the Lincoln and Continental plants and to distributor warehouses.

Not everyone knows that Doehler-Jarvis does extensive machining, finishing and sub-assembly work as well as die casting.

But it's true. Every Doehler-Jarvis Plant (8 in the U. S. and Barber Die Casting in Canada) mass produces sub-assemblies, as well as die casting and finishing basic parts. And you can rest assured, costs undercut those that customers might achieve in their own plants.

Costs are bound to be low. Doehler-Jarvis has in abundance versatile machining, metal forming and joining equipment plus finishing facilities that are unique. Experienced design, purchasing and production personnel, too. Everything needed to set up economical, continuous production, assembly, and packaging lines.

There are other savings, too . . . savings in *your* plant. Less tooling, for example. And you receive a responsibly inspected, fully functional sub-assembly ready for immediate use. Many D-J customers take delivery only on sub-assemblies needed for basic production. Spare-part production goes directly to customer's distributors.

Makes sense, doesn't it? Especially when you see, as in these three pages of pictures, how D-J handles typical production work.

Maybe you could push your costs down this way, too. Care to talk it over?

Doehler-Jarvis

DIVISION OF NATIONAL LEAD COMPANY

General Offices: Toledo 1, Ohio

In Canada:

Barber Die Casting Co. Limited

Hamilton, Ontario

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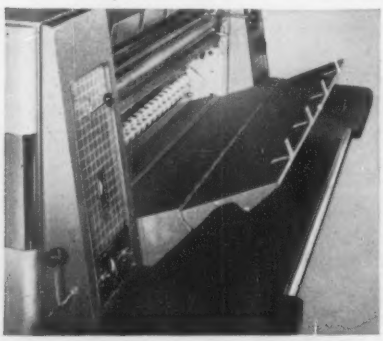
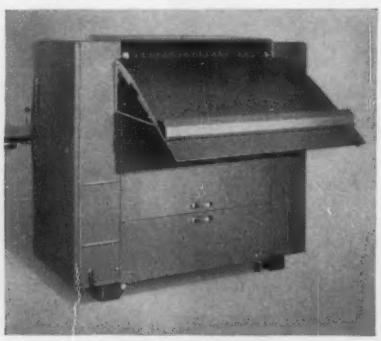
Now! Plan Ahead, Be Ahead

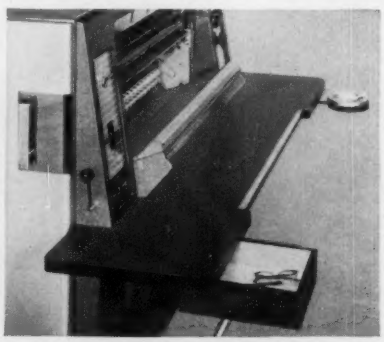
New front tracing tray can be adjusted in length to stack tracings up to 14 inches wide or up to 24 inches wide. Tray adjusts to stack tracings or to allow fast removal for re-insertion.



A flick of a lever provides front or rear print delivery. Rear print tray can be adjusted to different angles and to accommodate varied size prints up to 32 inches long. Roll-up attachment available.



Spacious 92-inch long feedboard is formica-surfaced with chrome-plated metal edge. Vacuum apertures hold roll and sheet stock in position. Drawer and swing-out ash tray provide added convenience.



with the Years-Ahead Reproduction Machine . . .

BRUNING COPYFLEX *Model 675*

Never before has a reproduction machine offered you so much to boost printmaking production, convenience and quality!

Never before has a reproduction machine been so "planned ahead" that it actually gives you TODAY the features you'll want and need TOMORROW!

Now, in Bruning's great new Copyflex Model 675, you get such radically advanced operational features as an exclusive four-way tracing tray that can be adjusted to stack or to permit fast removal of tracings . . . a unique system of vacuum ports in the feedboard that hold large sheets and roll stock in position . . . a feeder band system that eliminates curling and wrinkling of tracings . . . enclosed, easy-to-load feed rods for roll stock . . . an electrically controlled machine height adjustment. These and many other features . . . one-knob speed control, front or rear delivery, variable front print stacker, automatic separation . . . speed and simplify the operator's work as never before!

Providing optimum printmaking capacity are the 675's full 46-inch printing width . . . a mechanical speed of up to 75 f.p.m. . . . and a fast-printing 7,500 watt lamp variable to 5,000 watts at the flick of a switch Add to these a new filtered air system that assures a cleaner lamp cylinder, cleaner prints, and a consistently high rate of output. For extra speed and flexibility, a new split-shade lamp control enables simultaneous insertion of materials calling for different printing speeds.

All this and more is yours *now* in Bruning's all-new Copyflex Model 675! Act now to plan ahead and be ahead with the years-ahead reproduction machine. Available on convenient Lease-Purchase Plan. The coupon will bring you free descriptive literature.

BRUNING *Copyflex*

Charles Bruning Company, Inc., Dept. 113-K
1800 Central Road, Mount Prospect, Illinois
Offices in Principal U.S. Cities
In Canada: 105 Church St., Toronto 1, Ont.

Please send me more information on the new Copyflex Model 675.

Name_____ Title_____

Company_____

Address_____

City_____ County_____ State_____

Circle 426 on Page 19

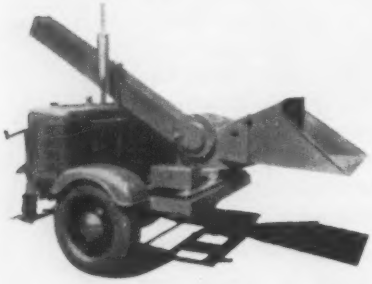
THE DODGE STEEL Ladle
BUSINESS MAGAZINE EDITION
PUBLISHED BY DODGE STEEL COMPANY
6501 Tacony Street, Philadelphia 35, Pa.

Notes on Dodge foundry engineered product improvements

More and more designers and purchasers of steel castings are taking advantage of Dodge's unique 3-way engineering service to obtain better, more efficient parts. Complete facilities are available at Dodge to assist in the proper design and specification of a proposed new casting . . . to review present castings in order to determine how they may be redesigned to save metal and increase strength . . . and to help in converting other metals and forms to steel castings. Here are typical examples of the effectiveness of this service:

INGENIOUS TREE CHIPPER

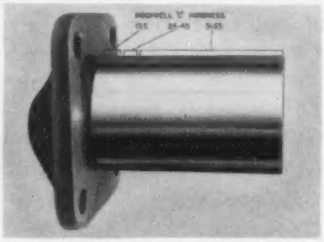
Helping to solve the brush disposal problem is this ingenious, portable Tree Chipper, that can be taken directly to the operation to "make little ones out of big ones".



A major part of the Chipper is a Dodge cast and machined steel roller, 9 inches long, 11½ inches in diameter and weighing 275 pounds. The cast steel roller, featuring three horizontal cutting blades, is so geared that it travels at a speed of 2,200 rpm. Brush and limbs up to 6" diameter are fed into the machine and cut up into small chips. The use of a quality steel casting in this application assures uniform, predictable results, as well as long service life.

FAREWELL TO BREAKAGE

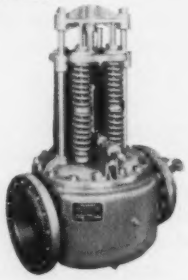
A well-known truck trailer manufacturer experienced extensive breakage of a trunnion pin in its trailer rear wheel tandem assemblies. The pin, used to support an equalizing beam, was not strong enough to take the punishing movement of heavy loads. New specifications called for a pin with a bearing surface ductile enough, yet with sufficient strength to do the job. Cost was to be kept low. Dodge designed, built, and machined the casting shown here.



The pin uses a special grade of Dodge steel which responds to differential grades of hardness along its surface, depending on the required stress demand. Result? Breakage problem eliminated with a steel casting produced at low cost.

STEAM LINE INSURANCE

In power plants and other systems utilizing high-pressure, high-temperature steam, the safety of workers as well as equipment is important. One safe and efficient pressure device—used in thousands of installations—is this relief valve made by a leading manufacturer.



Proper design coupled with the use of quality steel castings are good reasons why these valves have provided safe, efficient operation for so many years.

The best proof of the savings available to *your* company through the use of Dodge 3-way engineering service is the experiences of these manufacturers and others who have had problems similar to yours. This timely and valuable service is ready to go to work for you. May we study and solve your problem?

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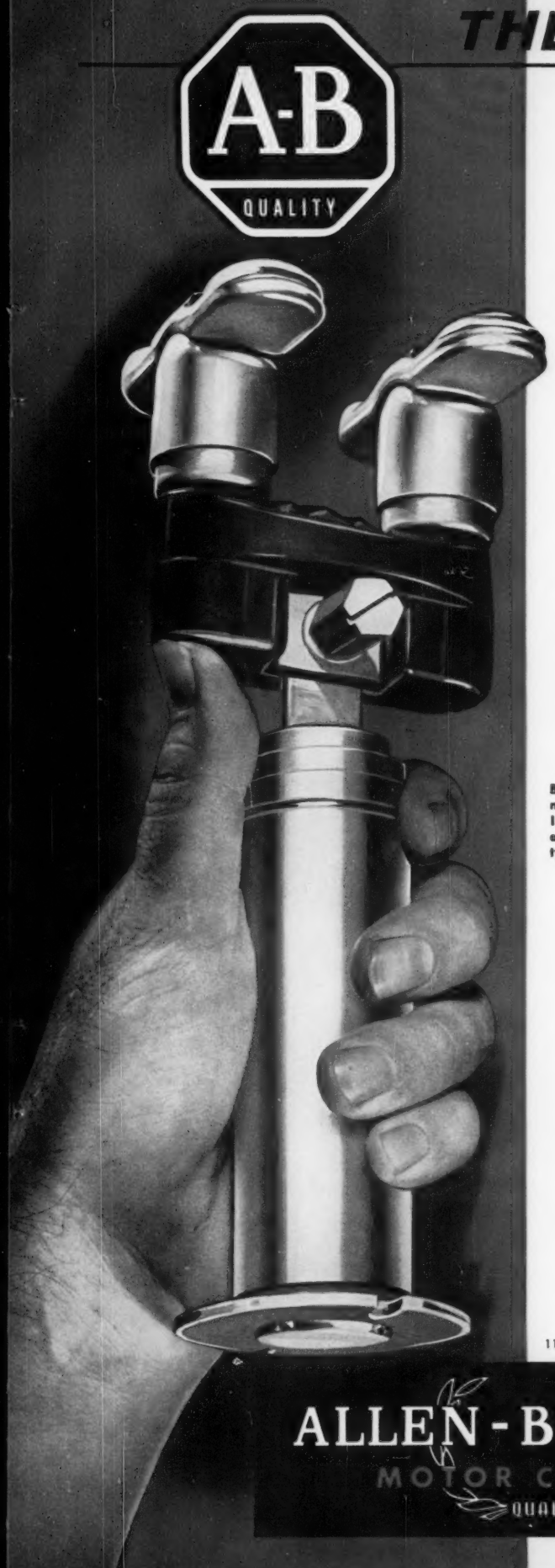
Circle 428 on Page 19→



THE ONLY LINE OF

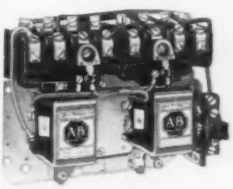
D. C.
MOTOR STARTERS
with modern
SOLENOID CONTACTORS

With Allen-Bradley, you get D. C. motor control that is *completely modern!* It uses the simplest switching mechanism yet conceived . . . the solenoid contactor with only ONE moving part. There are no bearings to stick . . . no jumpers to break. This assures millions of trouble free operations. And the double break, silver alloy contacts never need maintenance. Available in ratings up through Size 4. Write for details.

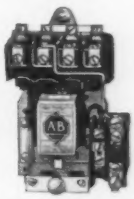
CONTACTORS

Bulletin 202 solenoid type contactor. In ratings to 150 amp. Also, clapper type to 600 amperes.

FULL VOLTAGE STARTERS

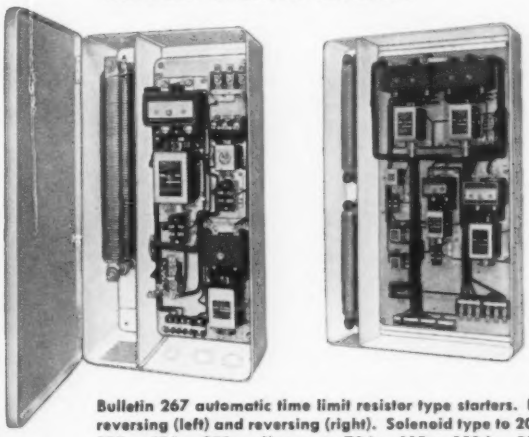


Bulletin 205 full voltage reversing starter. Ratings to 1½ hp, 115 v; 2 hp, 230 v.



Bulletin 209 full voltage starter. Available in ratings up to 1½ hp, 115 v; 2 hp, 230 v.

REDUCED VOLTAGE STARTERS



Bulletin 267 automatic time limit resistor type starters. Non-reversing (left) and reversing (right). Solenoid type to 20 hp, 115 v; 40 hp, 230 v. Clapper to 75 hp, 115 v; 150 hp, 230 v.

11-58-MR

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

MAIN OFFICE and Factory
1316 S. Second St.
Milwaukee 4, Wis.

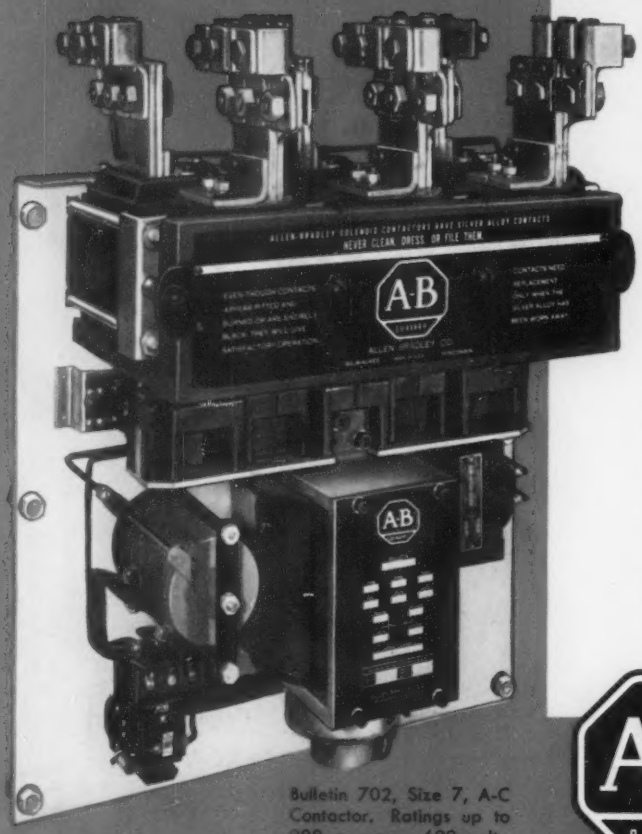
In Canada: Allen-Bradley Canada Ltd., Galt, Ontario

only

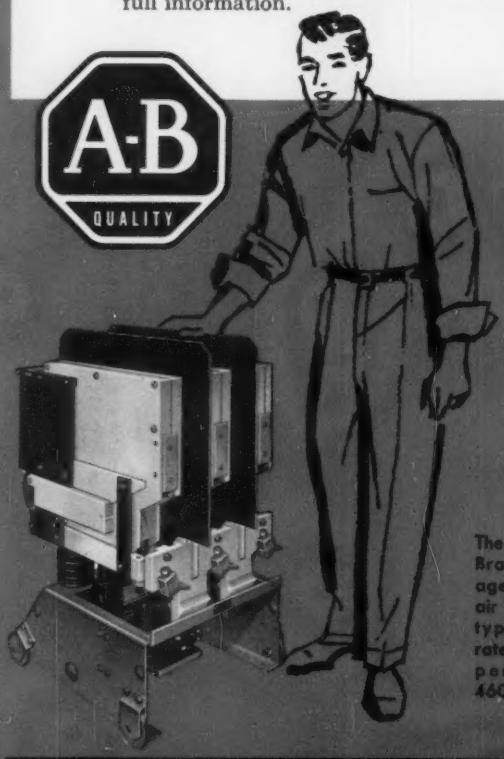
ALLEN-BRADLEY gives you Trouble Free Solenoid Starters in ALL SIZES!

The simple solenoid design—exclusive with Allen-Bradley in the big starter sizes—has only one moving part. This eliminates the trouble causing bearings and flexible jumpers of conventional clapper switches . . . and assures millions of trouble free operations. A-B solenoid starters also have double break, silver alloy contacts that never need any servicing. They are always in perfect operating condition—until the contact is completely used up.

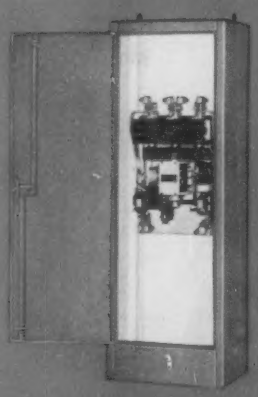
This time-tested solenoid construction is available on *all* Allen-Bradley starters up through Size 7 . . . as well as on A-B's rugged, air break, high voltage starters. Write for full information.



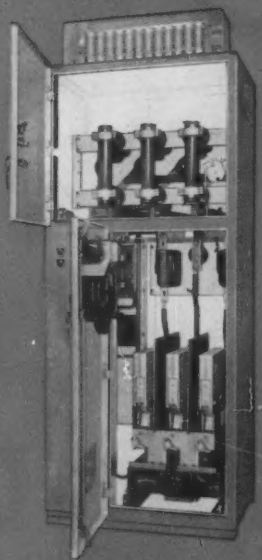
Bulletin 702, Size 7, A-C Contactor. Ratings up to 900 amperes, 600 volts. This basic solenoid contactor is used in large A-B low voltage starters.



The heart of Allen-Bradley high voltage starters is this air break, solenoid type contactor—rated at 400 amperes, 2300 or 4600 volts.



Bulletin 709 across-the-line solenoid starters are made in ratings to 300 hp, 220 v; 600 hp, 440-550 v.



A-B high voltage starters are built for all types of motors. Ratings to 1500 hp, 2300 v; 2500 hp, 4600 v.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
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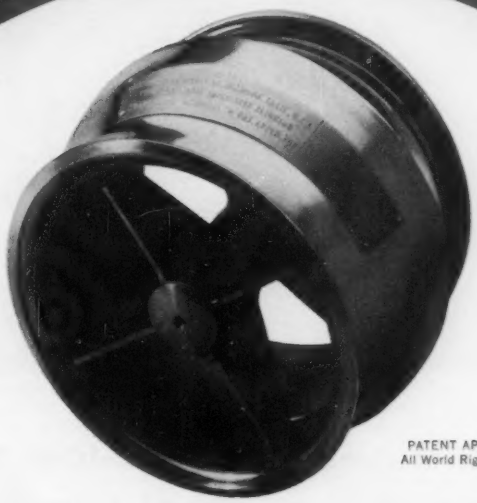
11-58-MR

"Flexhot"®

AIR DUCT JOINTS

SELF-ALIGNING ★ HIGH TEMPERATURE



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THOUSANDS OF FLIGHT SERVICE HOURS ★ HUNDREDS PRODUCED
FULLY QUALIFIED ★ U.S.A.F. ACCEPTED

After several years of development and a full year of flight testing, Southwest Products Co. now offers you "FLEXHOT" Air Duct Joints. New but fully tested and accepted. They utilize the proven "MONOBALL"® two-piece design with high precision workmanship.

Southwest's "FLEXHOT" Air Duct Joints assure years of trouble-free service. We welcome the opportunity to provide you with units to meet your individual requirements relative to flexibility, temperature, pressure, weight and material.

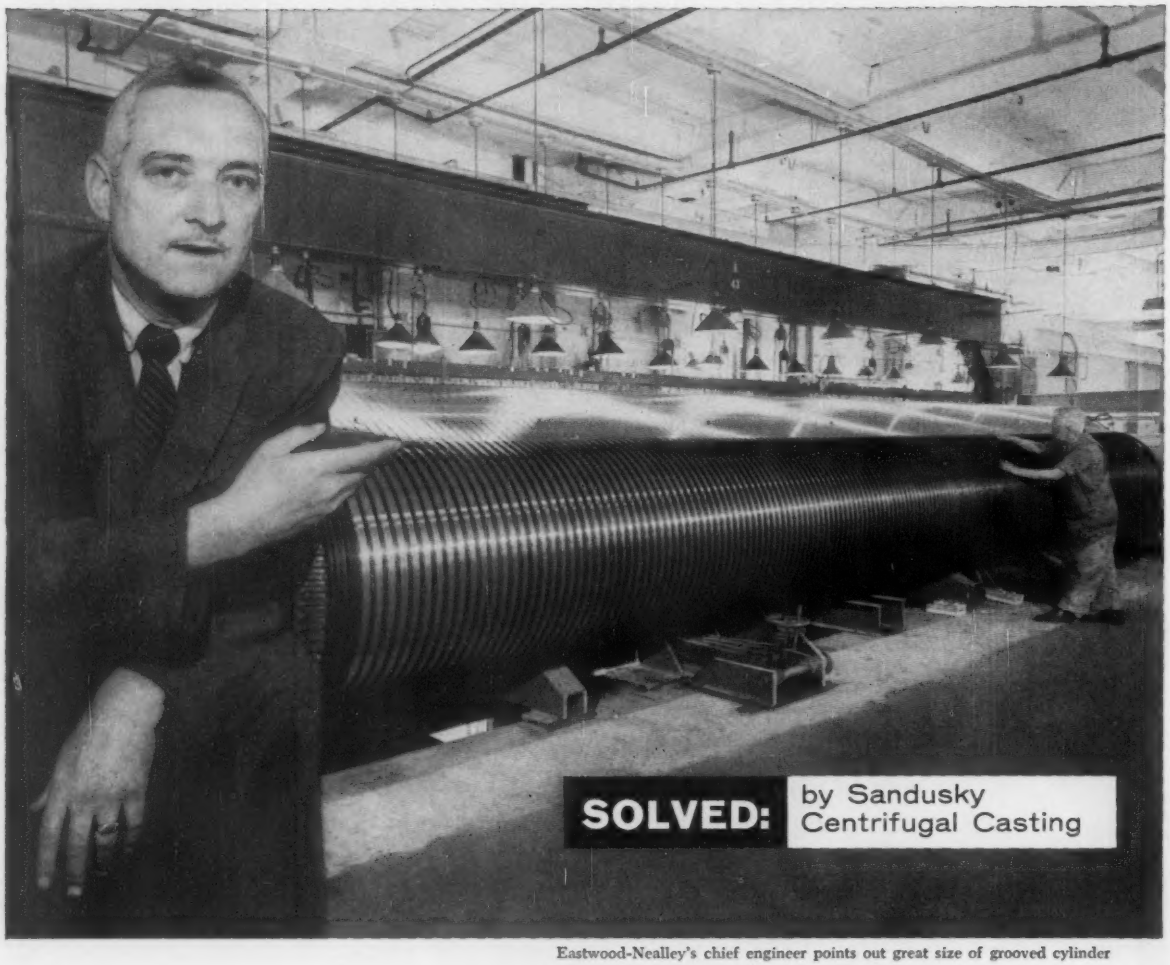
CHARACTERISTICS

1. 360° of Axial Rotation While Inline or Misaligned. ★ 2. Operating Pressure Range 0 to 110 PSI Gage.
3. Axial Deflection up to 10° Included Angle Between Ends. ★ 4. Positive Maximum Angular Control.
5. Minimum Bending Moment. ★ 6. Operating Temperature Range —65°F. to 550°F. Internal Air.
7. Minimum Torque. ★ 8. No Lubrication Required for the Life of the Unit.
9. Adaptable to Marman, Janitrol & Bolted Type Flanges. ★ 10. Minimum Pressure Drop.
11. 165 PSI Gage @ 550°F. Proof Pressure. ★ 12. Long Life.

SOUTHWEST PRODUCTS CO.

1705 SO. MOUNTAIN AVENUE
MONROVIA, CALIFORNIA

Circle 431 on Page 19



Eastwood-Nealley's chief engineer points out great size of grooved cylinder

Who else could cast this 22-ton cylinder for the world's biggest wire cloth loom?

To weave Fourdrinier wires up to 352" wide for the world's newest and largest paper machines, Eastwood-Nealley Corp., Belleville, New Jersey, required a cylinder over 30 feet long.

Sandusky supplied this 44,685 lb. roll, centrifugally cast of SAE-1030 steel and rough machined to 363" in length, 40⅝" on the O.D., to be used as the backbeam on Eastwood's new wire cloth loom. Since the cylinder had to be machined with 176 extremely smooth 2" x 2" stirs (grooves) in which wire is wound, it had to be of *flawless quality*. Otherwise any voids or inclusions exposed by machining would nick the delicate bronze strands and cause the expensive wire cloth to fail.

Eastwood-Nealley's chief engineer, Clemson A. Bower, asserts: *"We chose a Sandusky Centrifugal Casting because only Sandusky could make such a gigantic cylinder without welding. We were confident that our special machining operation would be accomplished without costly re-makes, for in the 12 years we have been using them, we never found a single flaw in a Sandusky Centrifugal Casting!"*

When cylinders or piping are needed in your design, keep Sandusky Centrifugal Castings in mind. We can supply cylindrical products from 7" to 54" O.D. and up to 33 feet long—made from a variety of alloys including stainless, carbon and low-alloy steels as well as copper- and nickel-base alloys. Send for free booklet, "Your Solution to Cylindrical Problems."

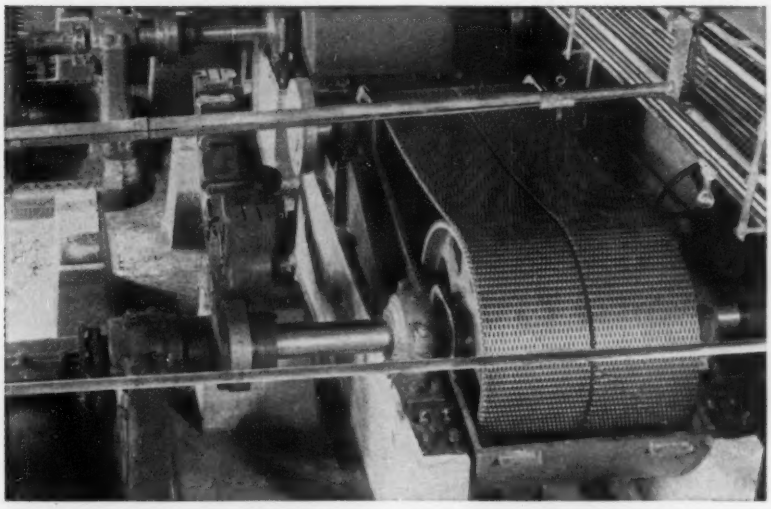
SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.

5804

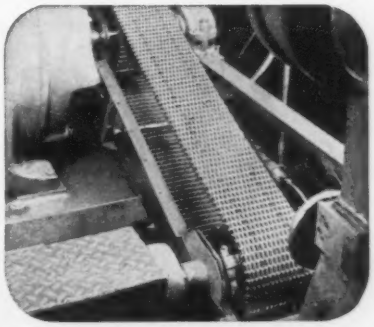
SANDUSKY, OHIO Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

How LINK-BELT silent chain comes through industry's stiffest tests

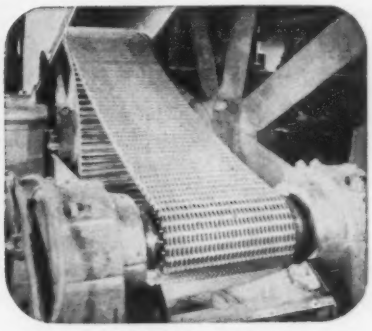
No other drive can do the same



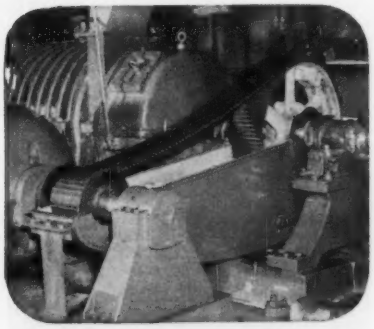
LARGE OR SMALL HP. Two 24-in. strands of Link-Belt silent chain on turbines powering 850-kw generators comprise one of the largest chain drives ever built. Silent chain provides high efficiency (over 98%) on large or fractional hp drives.



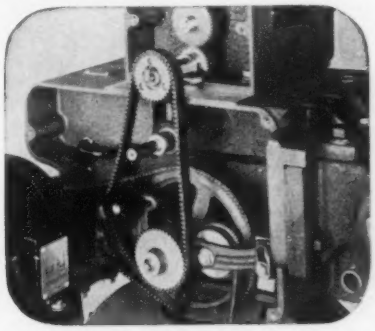
HIGH SPEED. Link-Belt silent chain drives on newspaper presses often operate at speeds of 4000 to 5000 feet per minute.



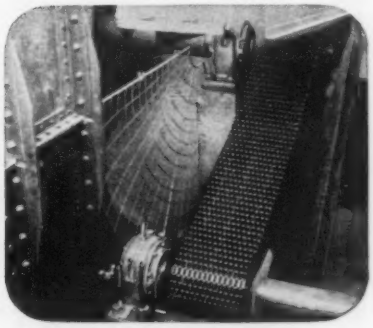
ADVERSE OPERATING CONDITIONS. Effects of heat, humidity and cold are minimized with Link-Belt silent chain drives.



LARGE RATIOS. Link-Belt silent chain operates efficiently at ratios as high as 10-to-1, with resulting space economies.



COMPACTNESS. A complete drive as small as your thumb—Link-Belt 3/16-in. silent chain is ideal for limited-space applications.



LONG LIFE. Link-Belt silent chain has given more than 30 years of uninterrupted service on ventilating systems.

Get in touch with your nearest Link-Belt office for

88-page Data Book No. 2425

LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,680-A

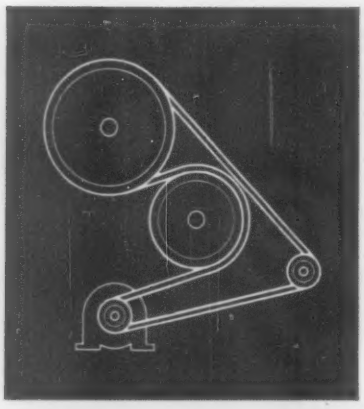
Circle 433 on Page 19

V-Belt Designer's Notebook

A special V-Belt Engineering Service to help you cope with 7 Drive Problems created by space-saving modern design

A checklist of V-belt drive designs which require specialized engineering. With a description of the compensating characteristics which can be built into special Dayton V-Belts. Sources: Case histories from the files of the Dayton Special V-Belt Engineering Service and "The Dayton Handbook of V-Belt Drive Design and Selection."

Here's a typical example of efficient, compact, modern design—an automatic washer with a Dayton V-Belt Drive.

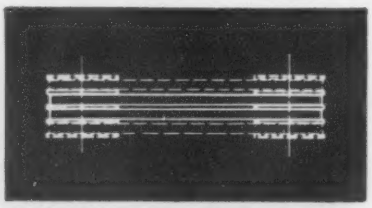


Note that it imposes three design requirements, (1) a torturous back bend (2) sub-diameter pulleys (3) a limited tension take-up area. Yet the design is efficient because Dayton V-Belt engineers developed a belt especially adapted to these three punishing conditions.

You'll find similar examples in machine tools, agricultural machinery and wherever drive space is limited. You've seen them yourself—the designs which dictate sheave misalignment, back-side idlers, underbelting; plus others which use V-Belts as a clutch and which impose excessive shock loads on the belt.

HERE ARE THE MAJOR CONDITIONS WHICH AFFECT V-BELT PERFORMANCE

Underbelting

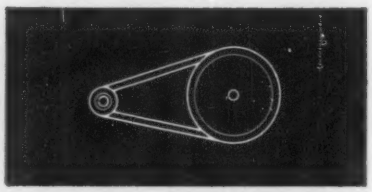


Underbelting is found where space is limited or as a result of very low belt speeds. It will cause belts to slip, run hot and wear out very quickly. A temporary cure, commonly employed, is to over-tension the belt — thus throwing excessive loads on the bearings.

The design requires a high capacity belt with extra-strength cords found in Dayton's Super-Thorobred series or, in difficult cases, belts with both a high coefficient of friction and extra strength like the raw-edge Dayton Cog-Belt.*

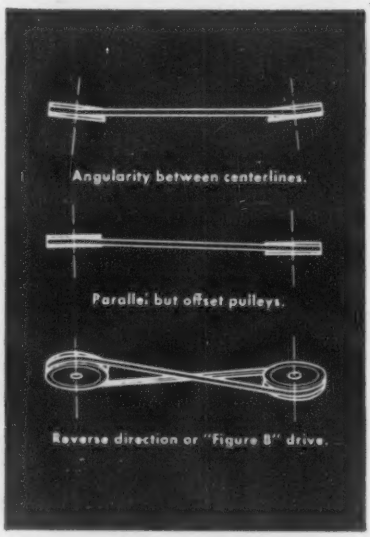
Sub-diameter sheaves

Belts driven by sub-diameter sheaves are inclined to succumb to accelerated flex failure. Tensioning problems are a usual result.



Sub-diameter sheaves require extremely flexible belts for satisfactory service. The required flexibility may be obtained by using thin V-Belts—where drive capacity is not high. When considerable capacity is required, Dayton Cog-Belts will give the most satisfactory performance. Their exclusive design permits exceptional flexibility. Die-cut raw edges provide high coefficient of friction, transmit maximum power from sub-diameter sheave arcs.

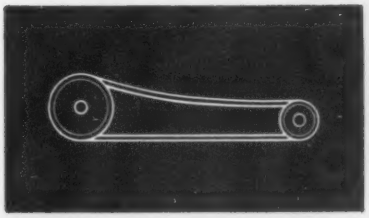
Misalignment



Misalignment causes uneven tension across the face of the belt—producing abnormal belt and pulley wear and uneven bearing loads.

A suitable approach is to use highly extensible cords of the latest synthetic fibers in the strength band of the V-belt. Dayton's Development Engineer can prescribe the material best suited to your needs.

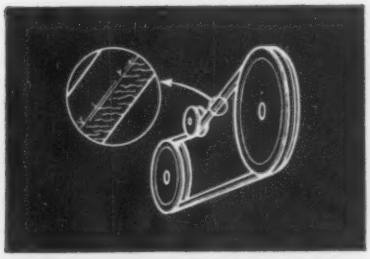
Fixed centers



Proper tension cannot be maintained with fixed centers or where center distance adjustment is inadequate. Without proper tension, belts slip and need frequent replacement.

Dayton V-Belts with low-stretch neutral-axis cords are best suited for applications with little or no provision for center distance adjustment. Still higher performance is gained if the belts have maximum cross-sectional stability which helps keep the belt from seating in the sheave groove.

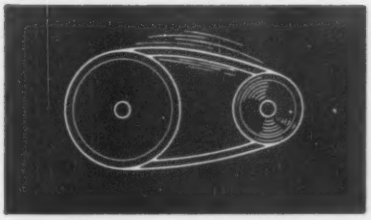
Back-side idlers



Cracks will appear on the under side of the belt, since back-side idlers force the belt to flex in a direction contrary to its construction. Use of spring-loaded back-side idlers may result in belt-snapping.

Where back-side idlers are used to provide tension take-up, they must never be smaller than the smallest pulley in the drive. Dayton V-Belts used in this case employ tension or stretchy type materials in the compression section and have a relocated neutral axis.

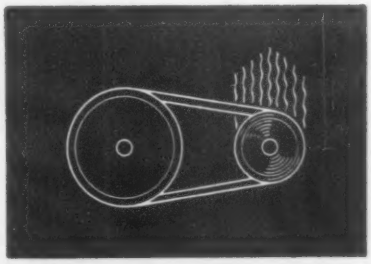
Excessive shock



Excessive shock can cause the belt to snap as well as promote bearing troubles and sheave misalignment.

Belts subject to excessive shock or heavy pulsation require strength band constructions which offer changeable ratios between stress and strain without taking a permanent stretch. Belts with soft cross sections — that will ride up and down in the groove — work well under shock as do wide angle belts. Any of these belts are available from Dayton.

Using as a clutch



V-Belts are ordinarily designed for constant loads and will burn when used as a clutch.

But, belts especially designed for use as a clutch will readily slip when a load is suddenly applied or released. Dayton cover stocks used here have a low coefficient of friction and high resistance to wear.

DAYTON'S SPECIAL V-BELT ENGINEERING SERVICE

Make use of Dayton's Special V-Belt Engineering Service when you encounter any of these designs. Your Dayton V-Belt design engineer is an expert who has devoted himself exclusively to V-Belt Drives. Your design may permit a minor modification which would adapt it to the use of low-cost standard V-Belts. Other standard Dayton V-Belts available for special applications are the Double-Angle V-Belt, the Double Cog-Belt, the Variable Speed Cog-Belt and the back-side idler V-Belt.

With one of the finest research and development laboratories in the industry, Dayton research engineers constantly advance V-Belt knowledge. They develop basic theory, prove the characteristics of the newest compositions and materials available to the rubber industry and test the performance of theoretical constructions. All of this acquired information is at your call when you need a special V-Belt.

Now, while your design is on the drawing board, is the time to call your Dayton V-Belt design engineer. He'll help you select the V-Belt which is tailored to your specific drive. The result — a compact, versatile design which meets all your minimum design requirements and one that will give its users years of trouble-free service.

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis.

*T. M. © D. R. 1957

Dayton Rubber

THE DAYTON RUBBER CO., INDUSTRIAL DIV., DAYTON 1, OHIO
WORLD'S LARGEST MANUFACTURER OF V-BELTS

If you haven't received your copy of Dayton's authoritative Handbook of V-Belt Drive Design and Selection, write for it now. Just give us your name, title, and the address of your firm.

Circle 434 on Page 19

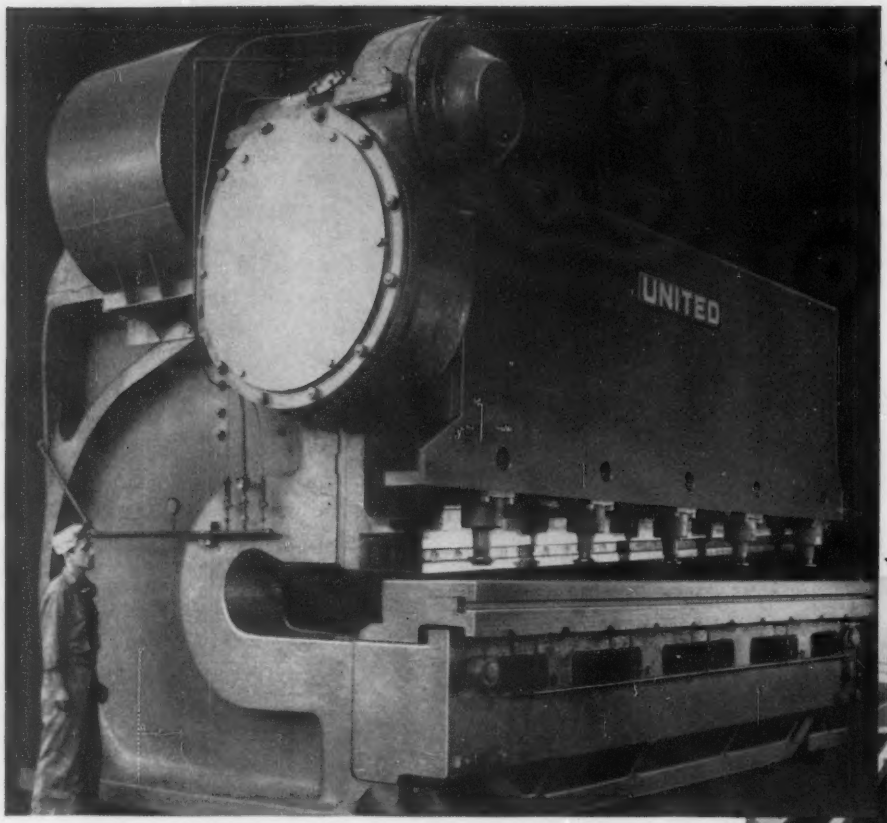
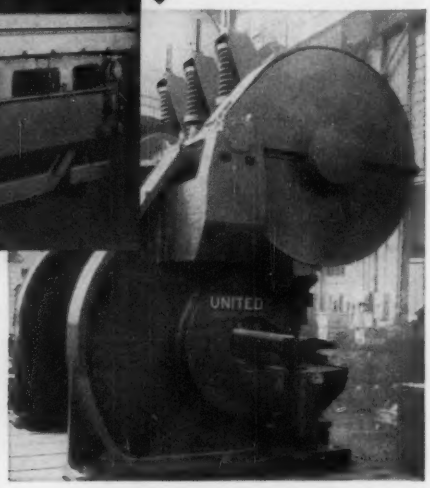


Fig. 1—United's 630,000 psi Cone-Drive geared shear is more compact and streamlined and has a higher capacity than the spur-gear driven shear. Cone-Drive gears are enclosed in compact housing in foreground.

Fig. 2—An older model of a similar shear shows the bulky conventional spur gear drive at the top of the machine.



WORM GEARED SHEAR CUTS 1 9/16" STEEL PLATE UP TO 13' WIDE

An idea of what double-enveloping worm gearing can contribute to steel mill equipment is told, in part, by the accompanying photographs. Fig. 1 shows a United Engineering and Foundry Company 630,000 lb. shear operated through Cone-Drive gearing. Fig. 2 shows an older similar shear—but actually of smaller capacity—driven through conventional spur gearing.

In addition to the reduced bulk and improved appearance of the newer shear, the following advantages have been obtained —largely by designing the shear around compact Cone-Drive gearing:

1. Capacity increased from 1" thick steel plate, 86" wide, to 1 5/16" thick and 156" wide.

2. Drive is enclosed and compact instead of cumbersome and sprawling.

3. Flywheel clutch unit and motor mounted to give more effective machine operation.

4. Service difficulties have been eliminated. Only an occasional check on lubricant is now required.

5. Much quieter and smoother operation.

The United shear develops up to 630,000 psi between the knives. Drive is from a 75 hp, 1000 rpm electric motor through a set of Cone-Drive gears with a ratio of 36.5 to 1.

This gearing is enclosed in the housing at the upper left corner of the machine in Fig. 1. The compactness of the gearing, making its complete enclosure simple, has contributed considerably to eliminating maintenance difficulties. According to one steel mill: "If we didn't have to check lubricant occasionally, we wouldn't know there were any gears in the case."

Reason for the compactness and freedom from trouble of the Cone-Drive gearing is that these worm gears—differing from others—are "double-enveloping" as a result of a special gear cutting process. In double-enveloping worm gears there are more teeth in contact and more contact per individual tooth. This results in a very high load carrying capacity required for steel mill equipment. It furnishes the positive action of a gear drive with the smoothness of a hydraulic drive.

Complete elimination of backlash is also possible with even the largest Cone-Drive gear sets. Compactness, high load capacity and light weight of these gears permit the use of much smaller gears and housings.

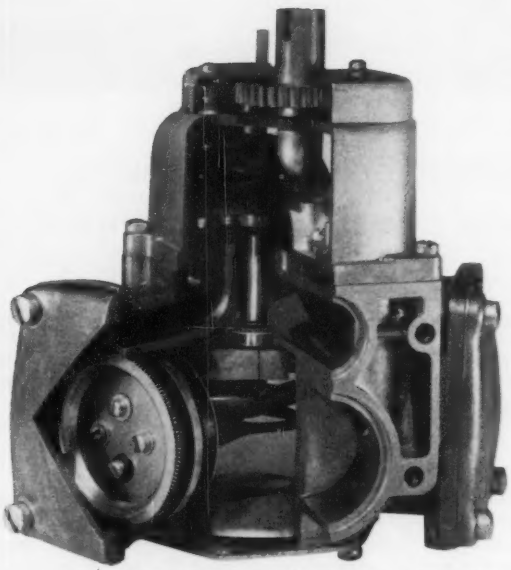
For further information on Cone-Drive worm geared speed reducers and gear sets, write Cone-Drive Gears, Div. Michigan Tool Company, 7171 E. McNichols Road, Detroit 12, Michigan.

Circle 435 on Page 19

VITON

TRADEMARK

A New Synthetic Rubber from Du Pont Serves Where Other Elastomers Fail



In this meter for gasoline pumps, the O-ring seal on the output shaft is exposed to aromatic components in high octane gasolines. A noted oil-resistant synthetic rubber was first used for the O-ring. It became swollen, however, and caused metering difficulties. When an O-ring of VITON was substituted, the trouble was eliminated.

Gives unequalled service in oils, fuels, solvents and chemicals at temperatures over 400° F.

VITON synthetic rubber combines high resistance to most fluids and corrosive chemicals with outstanding resistance to high temperatures—up to 450° F. in continuous service, up to 600° F. in intermittent service.

VITON offers excellent mechanical properties for a fluid and heat-resistant elastomer. Specimens return to within 90 to 97% of their original dimension after being compressed 25% for 70 hours at 250° F. At room temperature, tensile strength tests out from 2000 to 3000 psi, and ultimate elongation from 100 to 400%, depending upon hardness.

VITON is easy to process; components can therefore be made to close tolerances. This new synthetic rubber has already proved successful in precision seals (such as the one shown here), diaphragms, coated fabric and linings. To learn more about VITON, see your rubber supplier or send for our new booklet. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-11, Wilmington 98, Del.

RESISTANCE TO FLUIDS AND CHEMICALS

VITON vulcanizates were immersed for 7 days in a wide variety of corrosive fluids. These data show the effect of representative fluids upon the properties shown.	Tensile Strength Retained %	Hardness Change Points	Volume Increase %
Carbon tetrachloride, 75° F.	85	+ 2	1.3
Aniline, 75° F.	100	— 1	3
Tricresyl phosphate, 300° F.	93	—11	24
JP-5 petroleum aircraft fuel, 75° F.	100	+ 1	0.4
Turbo oil No. 15 diester lubricant (Mil-L-7808), 400° F.	60	— 6	19.6
Transmission fluid, Type A, 212° F.	77	— 1	1.5
OS-45 silicate ester, 400° F.	62	— 3	11.1
Sodium hydroxide, 46.5%, 75° F.	75	+ 1	2.1
Hydrofluoric acid, 48%, 75° F.	98	+ 2	4.8
Sulfuric acid, fuming, 75° F.	58	— 4	4.8

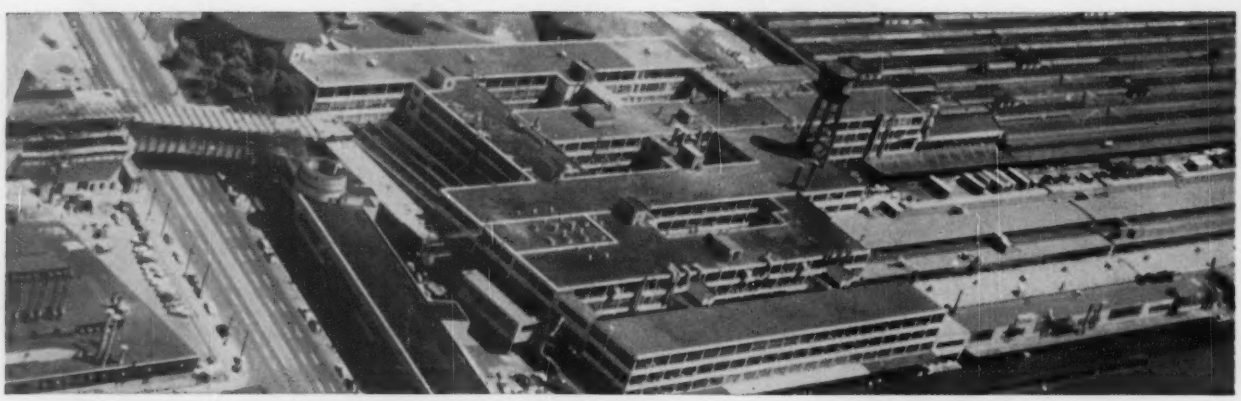
VITON

DUPONT

Better Things for Better Living
. . . through Chemistry

Circle 436 on Page 19

NEW... Expanded Facilities for



How Chrysler Marine and Industrial Engine Division is girding itself to bring you still better products and service

NEW EXPANDED PRODUCTION FACILITIES

A move to larger plant area with greater floor space devoted exclusively to the production of industrial engines now is being effected. Coordinated with the vast Chrysler engine building organization, these new facilities (included in the above illustration) will provide unmatched capabilities for supply of industrial engines to exact customer production schedules —with a minimum of lead time required. These expanded facilities also provide for faster design and manufacture of prototype engines for new customers.

NEW ENGINE CENTER-DEALER NETWORK

Strategically located Chrysler Industrial Engine Centers now are being established at service points throughout the United States. These new engine centers together with an enlarged dealer organization — plus five major parts plants and one master parts plant — make parts and service immediately available to the most remote user of Chrysler industrial power.

NEW EXPANDED FACTORY SALES AND SERVICE

To better serve manufacturers and users of power equipment, new regional and district offices are being opened with added personnel, including specially trained service men.

EXPANDED SALES-ENGINEERING SERVICE

Through new engineering procedures, specification of more than 2000 engine models in the standard product line has been simplified for immediate pricing and fast delivery. In addition, famed Chrysler engineering is available to all customers at all times on specific power applications.

EXPANDED PRODUCT DEVELOPMENT PROGRAM

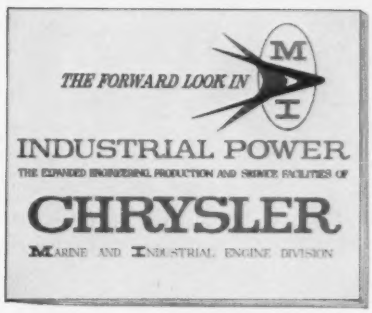
Intensified engineering research has been accelerated to still further widen the scope and improve Chrysler industrial power applications.

Chrysler powered equipment for every major industry.

Air Compressors
Aircraft Towing Tractors
Arc Welders
Concrete Mixers
Construction Pumps
Ditching Machines
Drilling Equipment
Fire Pumps
Farm Combines
Farm Tractors
Standby Generators
Hydraulic Cranes
Industrial Hoists
Industrial Tractors
Irrigation Pumps

Chrysler Industrial Engines

THE FORWARD LOOK IN INDUSTRIAL POWER



These new developments, plus the Hidden EXTRAS of Chrysler industrial engine supply service, have been detailed in a new brochure "The Forward Look in Industrial Power." It will be of extreme interest to power equipment manufacturers. A request on your executive letterhead will bring your copy.

CHRYSLER

MARINE AND INDUSTRIAL ENGINE DIVISION

CHRYSLER CORPORATION • DETROIT 31, MICHIGAN

Lift Trucks
Loading Machines
Mobile Cranes
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Petroleum Pumps
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Scoop Tractors
Shovels
Snow Mobiles
Street Sweepers
Winches
Yard Cranes

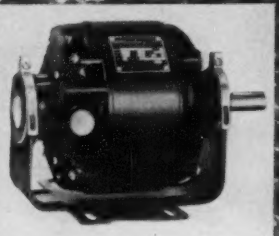
Circle 438 on Page 19

Here Experience Counts

Sure, sometimes luck helps out a fisherman . . . but in the long run it is experience that pays off. And it is experience that pays off when it comes to solving power-drive problems for appliance and equipment manufacturers . . . the kind of experience Emerson-Electric offers *you*.

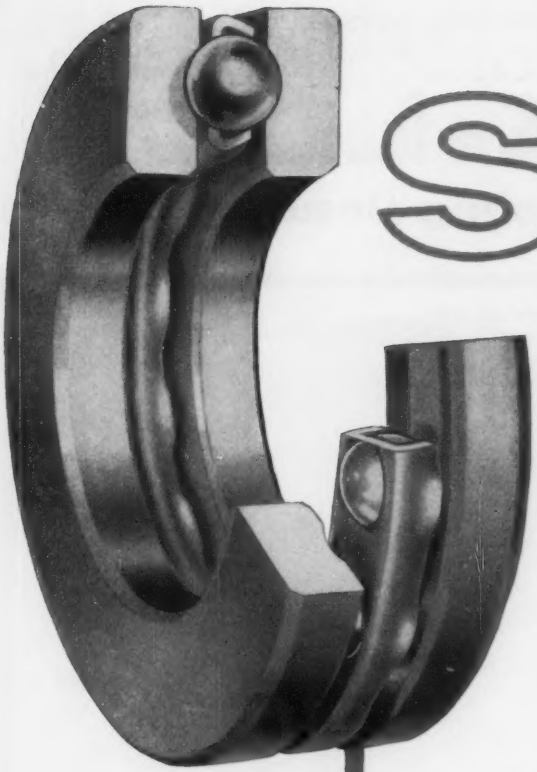
Remember . . .

- Emerson-Electric produces *custom-engineered* motors to suit *your specific needs*.
- Emerson-Electric has more than 100 engineers for on-the-spot service for *you*.
- Emerson-Electric has more than 65 years' experience in solving motor-drive problems *like yours*.



To get the kind of experience that counts, call, wire or write Dept. M-341 today. The Emerson Electric Mfg. Co., St. Louis 21, Mo.

EMERSON-ELECTRIC *of St. Louis · Since 1890*



SAVE with Aetna BEARINGS

DO YOU HAVE THE NEW AETNA GENERAL CATALOG AND ENGINEERING MANUAL?

Contains valuable engineering data, formulas, tables, design application drawings, shaft and housing fits, lubrication helps, etc. in a compact, readily accessible unit.

Secure your copy by phoning your local representative listed in your Classified Phone Book or write direct.

SAVE design adjustments and compromises

The Aetna line of quality precision bearings is so complete and diversified that within it there is undoubtedly the exact bearing, with the exact specifications, required for your design. No need to modify or change your design—no need to specify characteristics which require extra-cost handling.

This is especially true of Thrust Bearings—a field in which Aetna is the acknowledged leader—with a broad line of sizes and load ratings to meet practically all requirements from stock.

SAVE assembly costs

Precision dimensions held to exact tolerances guarantee press fit without effort or adjustment. Bearings received in perfect, factory-fresh condition, require no cleaning—no checking or inspection. Simply remove from carton, strip off the protective wrapper and install.

SAVE repair and replacement losses

Aetna bearings stand up under the loads and service for which they are designed—give long hours of perfect anti-friction performance—require no attention beyond periodic lubrication—seal out dirt, dust, grit and atmospheric impurities—and permit your equipment to deliver the fine, trouble-free performance which you have built into it.

AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURGH-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

In Detroit — Sam T. Keller — 1212 Fisher Bldg.

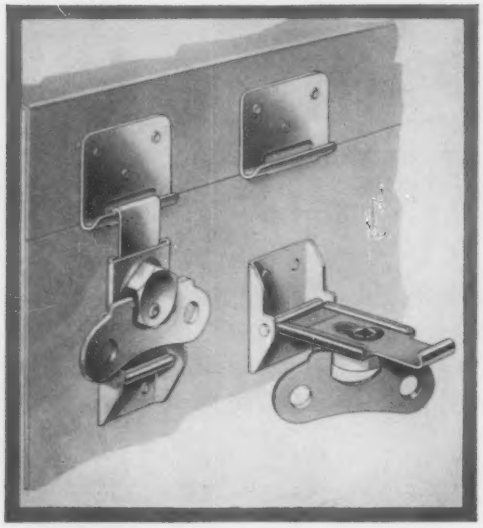
Aetna ANTI-FRICTION CONSULTANT TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

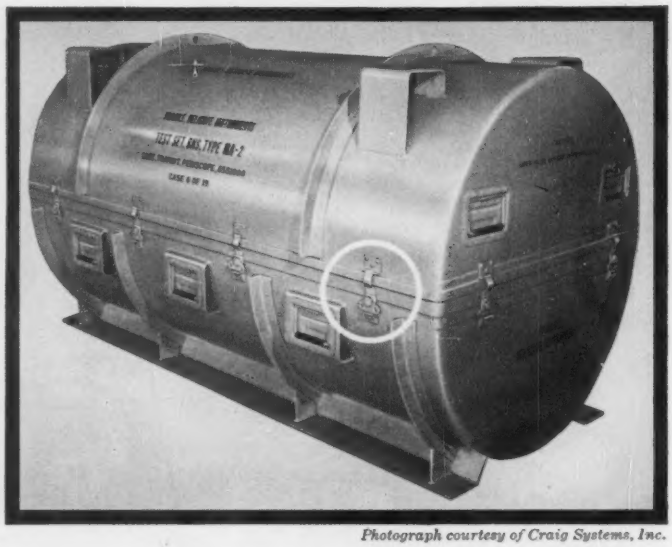
Circle 440 on Page 19

Note—Commercial and Military Packaging Engineers:

Rugged LINK-LOCK

...your best answer to exacting closure problems





Photograph courtesy of Craig Systems, Inc.

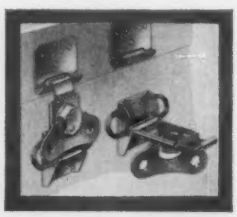
LINK-LOCK provides pressure-tight closure on this rigidly specified equipment container

Simmons LINK-LOCK provides quick opening and closing as well as impact-resistant dependability on transit cases manufactured by Craig Systems, Inc., Lawrence, Mass.

The cylindrical Craig container above is gasketed and pressure-tight, and contains delicate electronic equipment. Twelve LINK-LOCK fasteners are used on this model.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque..... insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design...lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.



Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

Where does the versatile Simmons LINK-LOCK belong in your design? For complete information and specifications, send for the Simmons Catalog today. Samples and engineering service available upon request.

SIMMONS
FASTENER CORPORATION
1756 North Broadway, Albany 1, New York
QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUALLOCK
See our 8 page catalog in Sweets Product Design File

Circle 441 on Page 19

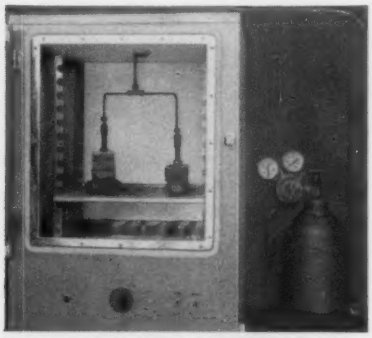
Technical data for gasket design and selection

NUMBER SEVEN

Choosing a gasket for service under high heat, high loads

Where gaskets are used under conditions that combine elevated temperatures and high flange loads—as for example in compressor heads and automatic transmissions—problems of extrusion and torque loss are likely to be met.

If internal pressures are also high, or if contained fluids or gases may attack the gasket—as in refrigeration



Laboratory test checks the combined effect of refrigerant gas and high temperature on Accopac AN-890. Flange at left contains refrigerant at 130 psi; flange at right contains no gas. After initial torquing at room temperature, flanges were heated to 300° F. and torque measured at 24-hour intervals for one week. Test showed no loss of torque on AN-890.

compressors—the service conditions become even more critical.

A new beater-saturated asbestos gasket that will seal under these rigorous conditions has been developed by Armstrong research. It is Accopac AN-890, a blend of refined asbestos fibers and nitrile-type rubber.

AN-890 withstands temperatures up to 800° F. and will not crush or extrude under test loads of 100,000 psi at 300° F. It has unusual torque retention and sealing properties in applications where heat, high flange loads, and high internal pressures are involved.

AN-890 is one of the Armstrong line of Accopac materials. It is available in rolls, sheets, or die-cut parts. For more information, write for a copy of our folder IND-915.

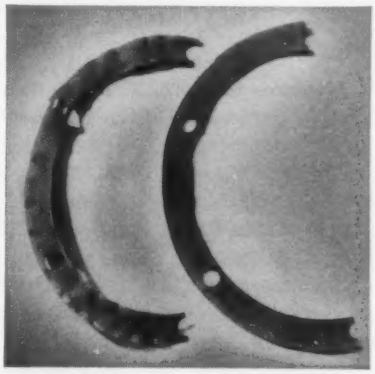
How contained fluids affect the choice of resilient gasket materials

When selecting a resilient gasket material, the possibility of undesirable interactions between the gasket and the contained fluid should be an early consideration.

The action of sealed fluids on a gasket takes two basic forms: *deterioration* and *shrinking or swelling.* Deterioration may result either in leaks or in contamination of the contained fluid. Shrinkage of a gasket, of course, ultimately results in leakage.

Within limits, swelling is not an undesirable reaction in a gasket. In fact, moderate swell can help create a more effective seal since it reduces the minimum flange pressure required for sealing. For example, Armstrong Accopac N-820 requires about 2,000 psi when sealing oil, but will seal a mixture of ethylene glycol and water at flange pressures of around 1,000 psi.

In judging the effect of fluids on a gasket, it is best not to rely on immersion tests of uncompressed samples. Porous materials, which absorb



These gaskets were used to seal hot oil. Ordinary plant fiber material (left) dried out and shrank. Armstrong Accopac gasket (right) was practically unaffected.

rather large amounts of liquid when unconfined, have radically different swelling characteristics when compressed. (See test photo at right.)

The effect of contained fluids can be controlled to some extent by proper design. Such things as bolt load, flange rigidity, and operating temperature should be considered along with the internal environment of the gasket. The maintenance of adequate flange loads, for example, will reduce the risk of fluid getting into the gasket or into the interface between the gasket and the flange.

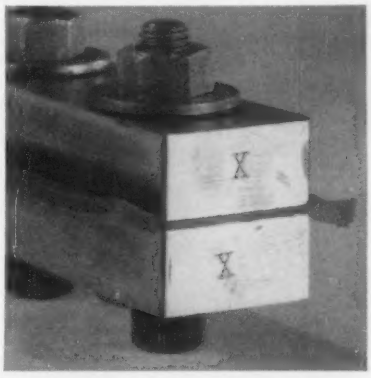


Photo shows difference in swell characteristics of fiber gasket. Test flange was immersed in gasoline. Gasket under compression remains at original thickness; unconfined material at edges swells to over twice original thickness.

Information on the effect of contained fluids on specific classes of gasket materials is contained in the Armstrong Gasket Materials catalog. Data on design factors related to gasket selection is available in the new Armstrong Gasket Design Manual. Write for your copy of either—or both—of these books today.

For your copy of Gasket Materials catalog or new Gasket Design Manual, write to Armstrong Cork Company, Industrial Division, 7111 Dean St., Lancaster, Pa.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

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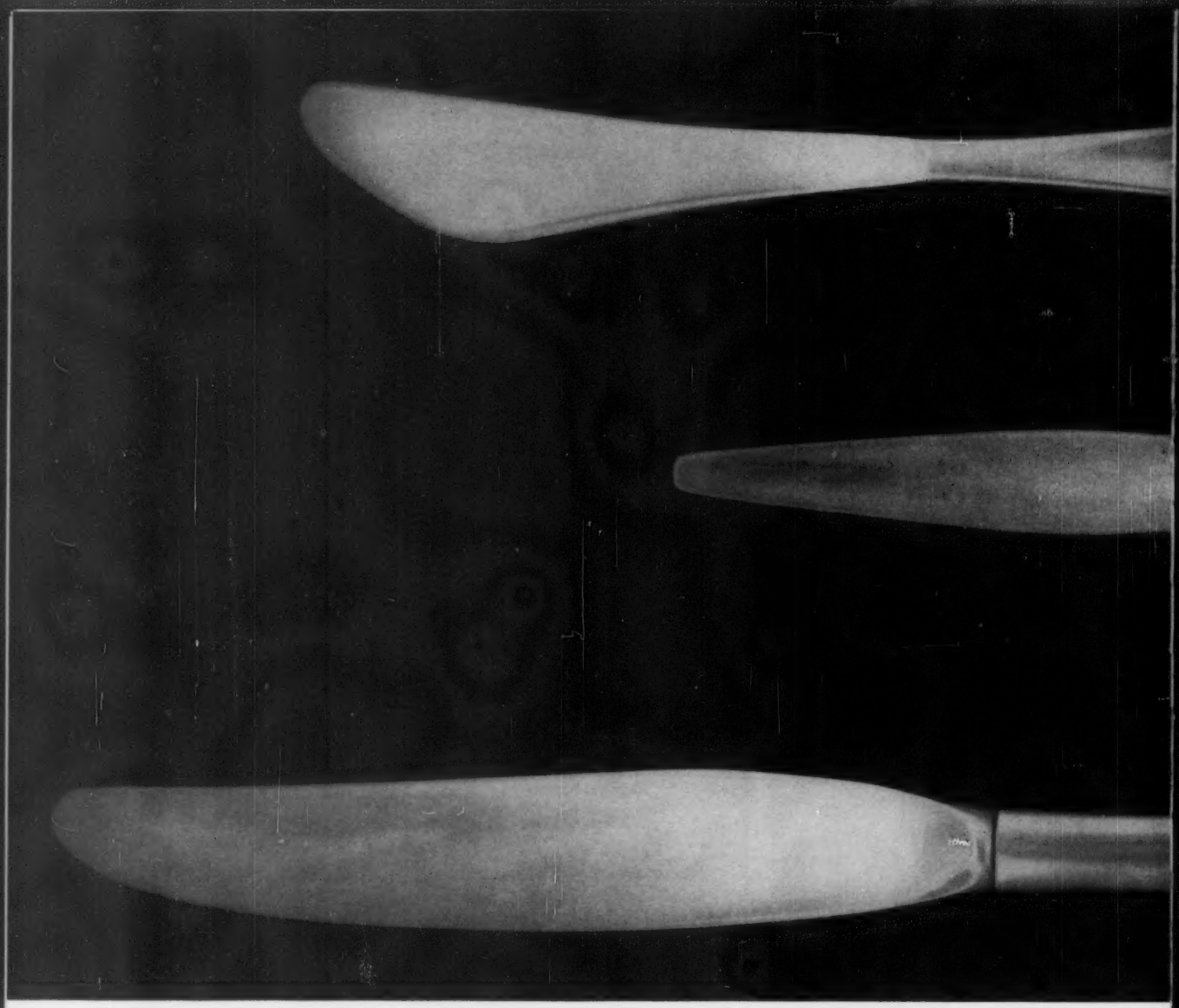


Good Design—Let's say that you were asked to design a *fish*. It's to be the most ferocious monster of the deep, a murderous creature ideally adapted to the sea. Chances are you would end up with something much like a 40-foot-long Great White Shark.

Then assume that you were asked to design the most efficient possible device to span a large body of water. You would very likely end up with something like the familiar high-towered suspension bridge.

You could then take these designs to any great artist and he would say, "They are beautiful"—even if he didn't know how or why you had designed them.

Why are they beautiful? Probably because they are so absolutely functional. In the astringent design of a fish or a bridge, lines are curved only when they should be curved—to add strength or streamlining. *Materials* are used functionally, too. You don't make a shark's tooth from cartilage. You don't make a suspension bridge from anything but steel.

As we develop more and more "styled" products, the choice of material becomes very important. For example, the flatware industry has been revolutionized by Stainless Steel because of its unbeatable combination of luster, strength, corrosion resistance and formability. The landscape gleams with steel curtain wall buildings as we learn to use steel in bold, bright, colorful ways. Even huge power shovels take on a new beauty as ultra-strong steels slim their silhouettes.

It's the same story with thousands of other products. And for any application, there is one steel best suited for the job—one that contains physical properties, appearance and price in the right package. It can be selected from the large family of USS Design Steels: Carbon, High Strength, Alloy and Stainless.

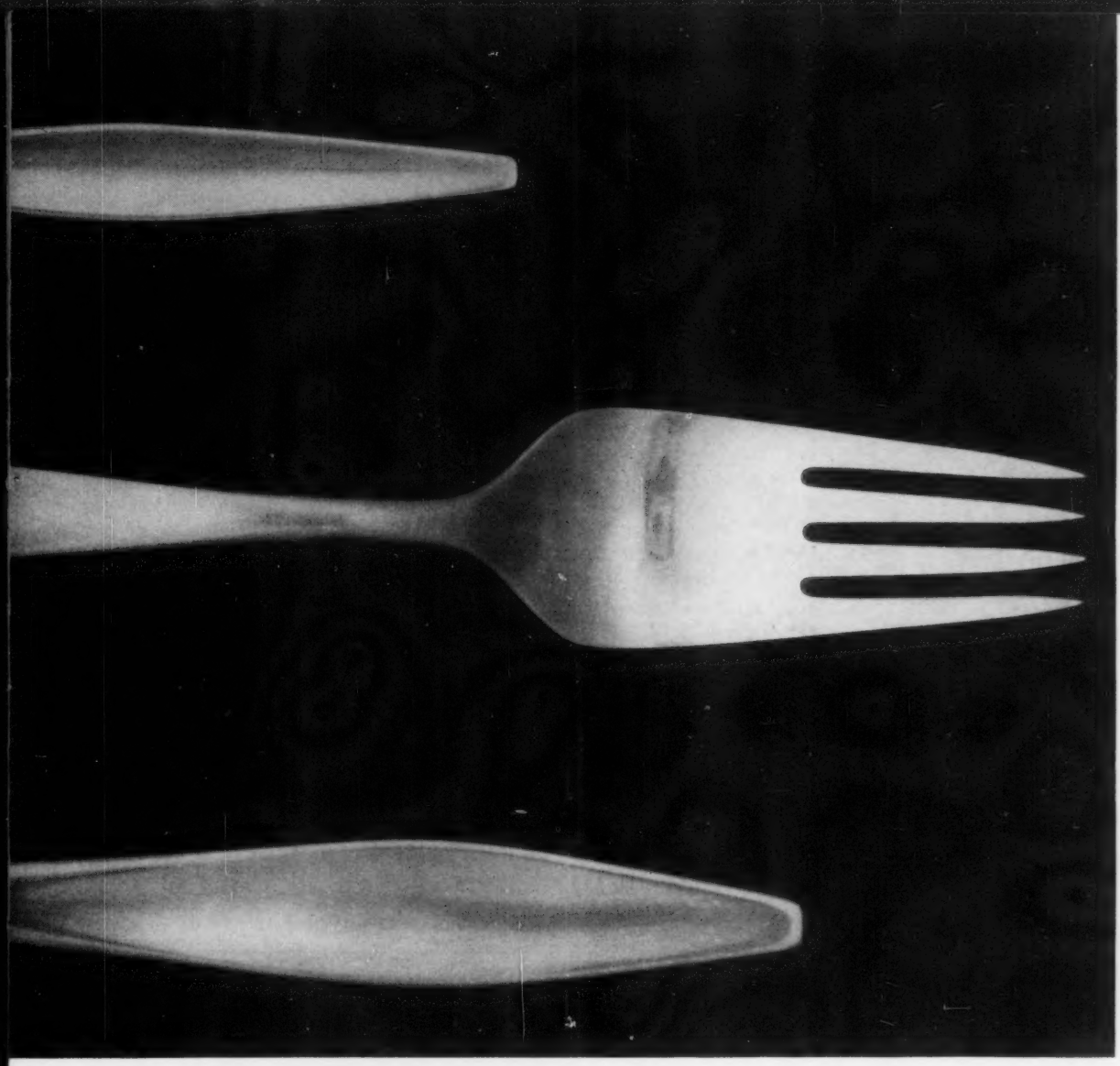
Any time you want help in making that selection, call United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS **United States Steel**

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

STEELS FOR DESIGN

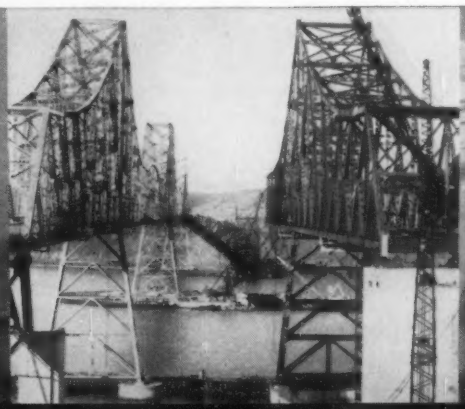


Lower Left: Problem: Combine ruggedness, safety, and beauty in a pleasure yacht. Solution: Designer used USS COR-TEN High-Strength Low-Alloy Steel. Pay-off: Hull is stronger and more resistant to corrosion. Welded construction allowed separation of the gasoline and bilge areas, helps eliminate the most common boat disaster—fire. Formability of COR-TEN made it easy to shape the sleek, curving hull.

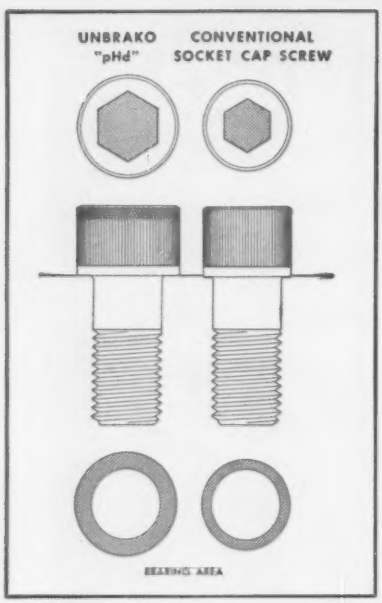
Lower Middle: Match profile of a new cantilever bridge (right) with existing bridge, but build it stronger to support wider roadbed. Solution: USS "T-1" Constructional Alloy Steel (now available at 100,000 psi min. yield strength) and USS TRI-TEN High-Strength Low-Alloy Steel. Pay-off: "T-1" Steel alone saved $800,000 by slimming down massive members. All shop connections are welded. "T-1" 's weldability enabled clean, graceful members contrasted to laced and riveted members in old bridge.

Lower Right: Problem: Portray 20th century Pittsburgh in a metal mural for a Pittsburgh hotel. Solution: Artist selected Stainless Steel for most of the job. Pay-off: A mural that is permanently beautiful. Says sculptor Rene Shapshak, "This is the Stainless Steel Age."

USS, "T-1", Cor-Ten and Tri-Ten are registered trademarks



Up to 233% more holding power with NEW UNBRAKO *pHd** socket cap screws



pHd stands for "proper head design"—a factor in higher product reliability

Enlarged head diameter, without change in head height, increases usable fastener strength as much as 134%, provides as much as 233% more holding power. The greater clamping force achieved with the new UNBRAKO pHd means longer fastener life under dynamic loads, offers the following advantages:

- Miniaturization. Space and weight-saving through use of smaller diameter or fewer screws. The 170,000-190,000 psi of these fasteners can be used to greater advantage.
- Reduction of fatigue failures. pHd allows consistently higher preloading, a major factor in lengthening the fatigue life of threaded fasteners.
- Fewer loosened threaded fasteners under shock or vibration.
- Eliminates washers under the heads of cap screws where they are used to increase the effective bearing area.
- Minimizes effect of oversized holes on the head-bearing area.

The head diameter, enlarged on 5/16, 7/16, 9/16‡, 5/8, 3/4, 7/8 and 1 in. sizes, also prevents the screw head from indenting the material being assembled—a fault that normally reduces, and sometimes completely loses, the vital preload or tensile stretch that keeps the screw tight and prevents fatigue failure. pHd also provides room for a bigger socket, which permits tightening to higher recommended preloads.

COMPARISON OF UNBRAKO pHd AND CONVENTIONAL DESIGN

Each size can now be utilized with equal reliability. The bearing stress is consistent from size to size in the new UNBRAKO pHd socket cap screws.

SCREW SIZE	HEAD DIAMETER (in.)		BEARING AREA (sq. in.)		LOAD TO INDENT IN CAST IRON (lb.)		% INCREASE USABLE STRENGTH	TIGHTENING TORQUE (lb.-in.)†	
	Old	pHd	Old	pHd	Old	pHd		Old	pHd
1/4	.375	.375	.041	.041	3,280	3,280	–	165	180
5/16	.438	.468	.047	.072	3,760	5,760	54	325	360
3/8	.562	.562	.102	.102	8,150	8,150	–	600	660
7/16	.625	.656	.116	.148	9,270	11,800	27	1,000	1,040
1/2	.750	.750	.188	.188	15,000	15,000	–	1,450	1,590
9/16‡	.812	.843	.209	.247	16,700	19,700	18	2,050	2,270
5/8	.875	.937	.203	.305	16,200	24,400	51	2,900	3,190
3/4	1.000	1.125	.223	.432	17,800	34,600	94	5,050	5,600
7/8	1.125	1.312	.254	.594	20,300	47,500	134	8,000	8,900
1	1.312	1.500	.364	.785	29,100	62,800	116	10,550	13,600

†Normal recommended seating torques for unplated screws, fine threads ‡Available as a special only (listed for dimensional data)

High Reliability

SPS research is continually developing fasteners with higher and higher standards of predictable performance. By installing SPS high reliability fasteners in your assemblies, you increase your overall product reliability.

"High Reliability" is a booklet just published by SPS. Write for your copy today.

The new UNBRAKO pHd socket head cap screw is now available through all authorized industrial distributors at no increase in price. Specify UNBRAKO pHd when ordering. For technical data and specifications, send for Bulletin 2406. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

We also manufacture precision titanium fasteners / write for free booklet

SPS Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

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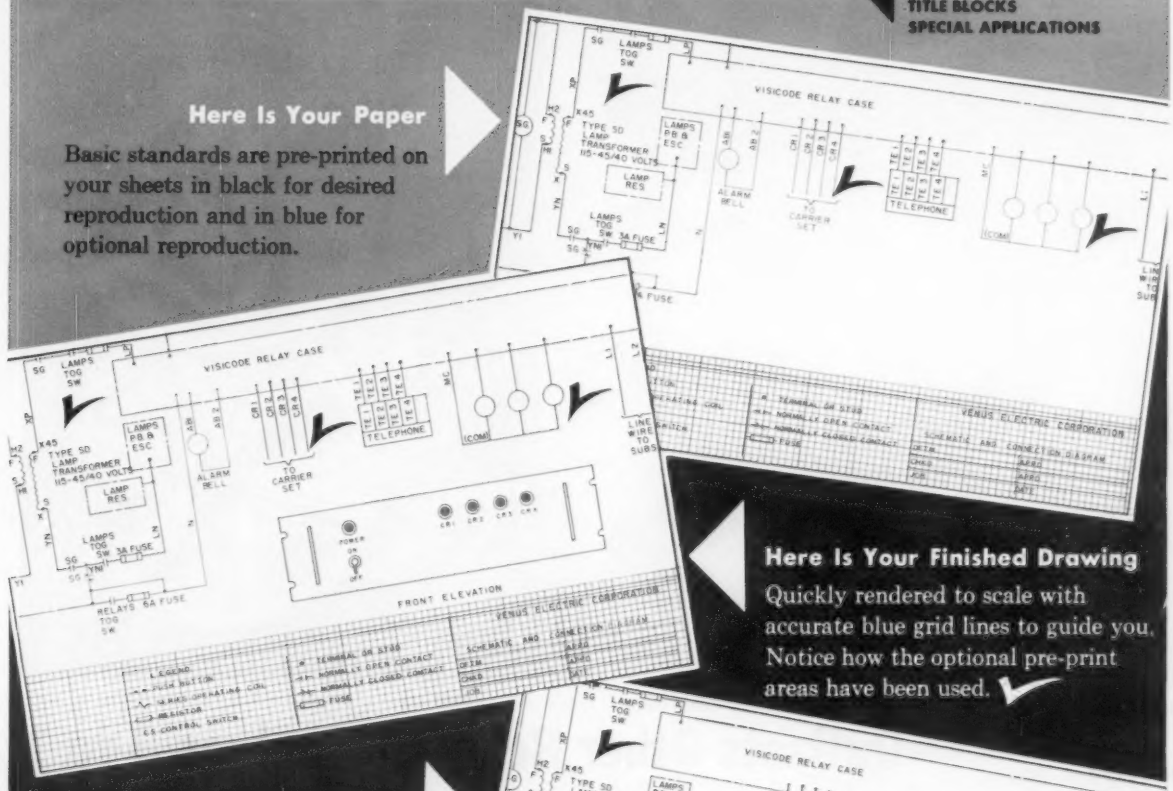

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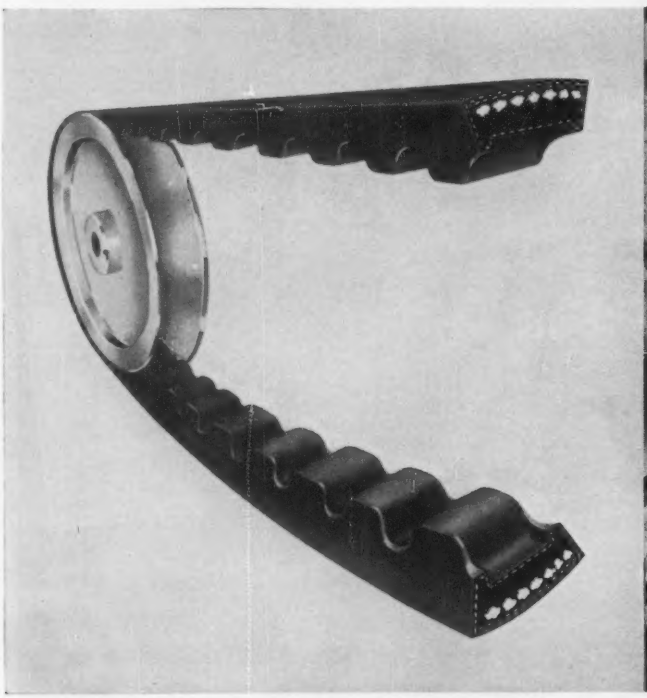
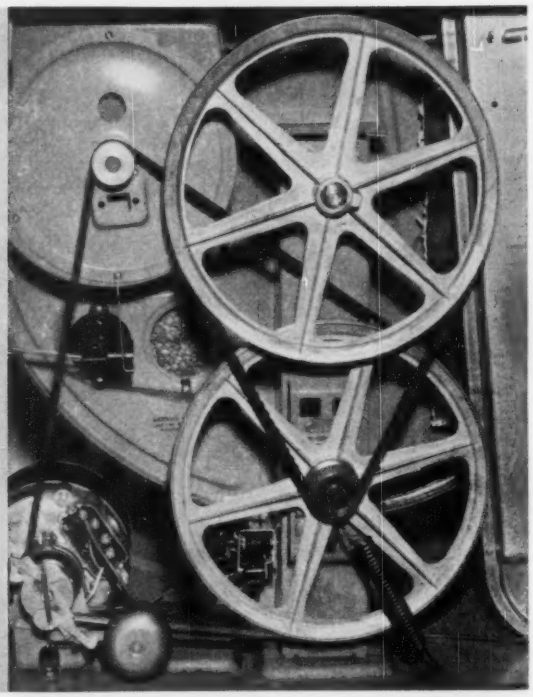
Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division, Raybestos-Manhattan, Inc.
Passaic, N.J.





NOW...A NEW DESIGN IN COG V-BELTS

Outlasts Other Belts as Much as 8 to 1

R/M introduces the new CX Cog V-Belt . . . *the only fully molded, fully jacketed cog belt*. Extensive tests have proved it outperforms, outlasts other makes of belts as much as 8 to 1. Fully molded and full fabric cover prevents flex-cracking, improves fatigue resistance, has less distortion because of lateral stability, maintains more effective length. It's the ideal cog belt for small pulleys where flexibility and ruggedness, with extremely quiet running, are important factors.

Other R/M V-Belt Designs

R/M engineering makes other V-belts to meet a wide variety of light and heavy duty requirements. For example, R/M FHP V-Belts eliminate troublesome vibration problems on motorized appliances, air conditioners, power tools. An exclusive molding process positions and controls every belt part to assure balanced belt power delivery without whipping or slapping.

On heavy duty multiple belt drives, Condor V-Belts with flat sidewalls assure *more* grip, *less* slip . . . longer belt life. (Write for Bulletin 6868).

For extra horsepower, R/M Super-Power V-Belts transmit 40% more power than conventional V-belts. You can increase drive power without changing drive design—or meet specifications with *fewer* belts. (Write for Bulletin 6628).

Space saving, no matching problems, and other advantages of the patented R/M Poly-V Drive, a revolutionary new concept in heavy duty power transmission, are detailed in a special Bulletin No. 6638.

Let R/M rubber specialists work with you on V-belts, transmission or conveyor belting, rubber hose, molded or extruded parts.

R/M

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

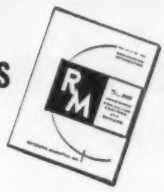
Industrial and Automotive Hose

Conveyor Belts

Circle 534 on Page 19

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

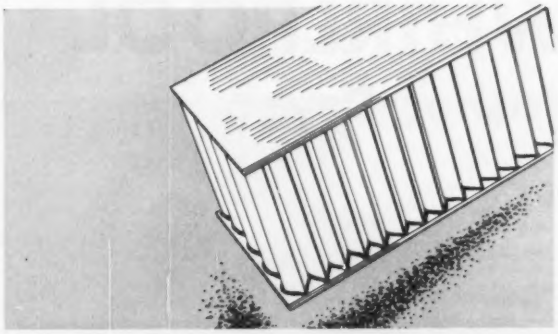
ADHESIVES



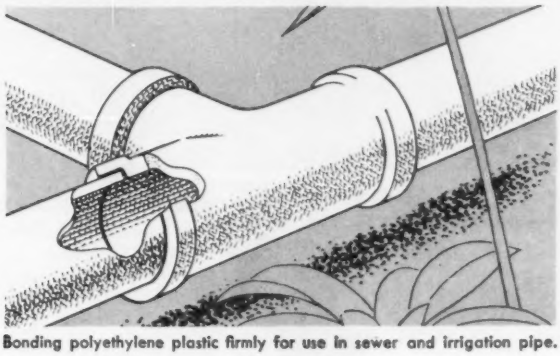
Send today for free copy of R/M Bulletin No. 700 on Ray-BOND adhesives, protective coatings and sealers.
Adhesives Department
Raybestos-Manhattan, Inc.
Bridgeport, Conn.

PACKINGS

Complete information on packings shown and many others is given in free booklet. Send for it today.
Packing Division,
Raybestos-Manhattan, Inc.
Passaic, N.J.



Resin-treated paper bonding to metal saves weight in this honeycomb.



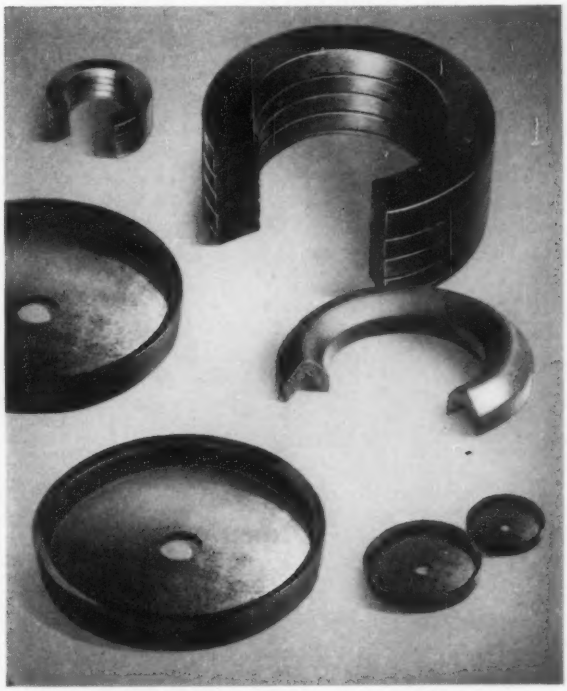
Bonding polyethylene plastic firmly for use in sewer and irrigation pipe.

Cutting Costs—and Corners in Product Assembly

With costs up and profits down, today is a better time than ever to check the advantages of adhesive bonding.

R/M Ray-BOND® Adhesives are now speeding assemblies and saving money in a broad range of different applications. Ray-BOND Adhesives have excellent bonding qualities and heat stability. They resist temperatures from −80°F to +700°F—give superior performance in meeting widely varied requirements, under many different destructive liquids, gases, atmospheres and physical conditions. And they have an impressive record for simplifying assemblies that were formerly difficult or impossible.

With over 20 years' pioneering in the production of bonded assemblies and the manufacture of adhesives and coatings, Raybestos-Manhattan is in a special position to demonstrate what adhesive bonding could do for you. Write for more specific information on your business letterhead now.



R/M Fabric Piston Cups — R/M Vee-Flex Rings

Controlled molding assures dimensional uniformity in R/M Piston Cups and "V-Rings"

R/M piston cups for hydraulic and pneumatic cylinders are designed and precision molded from a wide variety of modern synthetics to give maximum service with a minimum of friction. The clearly defined contours and cleanly trimmed edges assure strict adherence to industry's standard sizes. They are produced in varying degrees of hardness for pressures up to 1500 psi. Our engineers will gladly recommend the proper R/M piston cup for your specific operating conditions.

R/M Vee-Flex® packing rings, for use on steam or air rods, hot oil pumps, hydraulic cylinders, rams, presses, lifts, and a wide variety of other equipment, and precision molded in five types in varying degrees of hardness. They are self-sealing and self-adjusting for pressures up to 1500 psi.

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Asbestos Textiles

Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

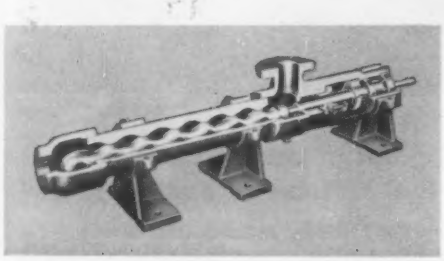
Engineered Molded Rubber and Plastics

MOYNO® Pumps Oceans

(Pebbles and all) for

RCA WHIRLPOOL

Washer-Dryer



Industrial type Moyno . . . available to 500 gpm, pressures to 1000 psi.

Whirlpool Corporation needed a pump with high suction and positive displacement for its automatic combination Washer-Dryer. Though sparing of water during wash-and-7-rinse cycle, each RCA Whirlpool combination circulates oceans during its long life. A Moyno Pump provides the continuous, uniform flow, 1 to 15 gal./min., free from air locking. Most important, even relatively large particles—sand, pebbles, children's pocket loot—can't stop a Moyno Pump!

In fact, Moyno's revolutionary, yet simple design can pump anything that can be forced through a pipe! A helical screw-like rotor turning inside a double-helical stator forms progressing cavities that don't squeeze . . . can't stick or gum up . . . will not cause churning, foaming . . . won't aerate or vapor-lock. On OEM products and in pilot plants, small Moynos solve pumping problems that are different, difficult or downright destructive to ordinary pumps. Write today for Bulletin—50-MD!

R&M

ROBBINS & MYERS, INC.

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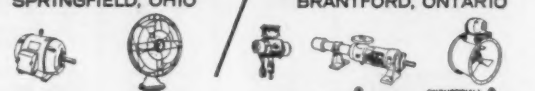
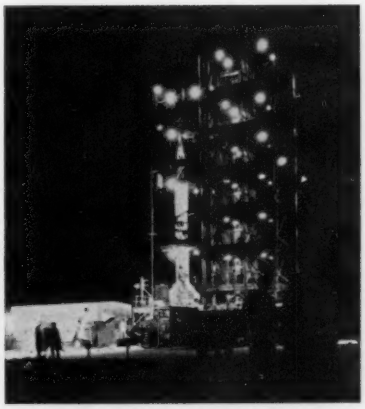


Circle 445 on Page 19

PRODUCT-DESIGN MEMOS FROM DUREZ

Insulative molding compounds | **Corrosion-resistant polyester** **Low-cost control knobs**



Official U. S. Navy photo

But what if it rains?

From time immemorial, weather has upset the military plans of men. In colonial days, wet gunpowder could lose a skirmish. Today, one moisture-affected part can nullify months of costly labor on a new missile.

This helps to explain the increasing pressure on moisture-resistant insulations for electronic parts that must not fail. It explains, too, the growing interest in a relatively new Durez molding material, *diallyl phthalate*.

This is the *only* plastic that retains its high insulation values over extended periods at relative humidities above 90%.

Its arc resistance, as measured by ASTM D495 (Method A or B), can be consistently reproduced.

It does not corrode metal contact points.

Because it is a thermosetting material, it provides virtual freedom from cold flow and creep.

You can get this material from us as an orlon-filled granular blue or green molding compound with plasticity values of 10, 12, or 16 by ASTM D731. It is designed to meet the requirements of Mil-M-18794, Type SDI-5.

For a data sheet detailing properties of the compound, and of molded material, check the coupon.

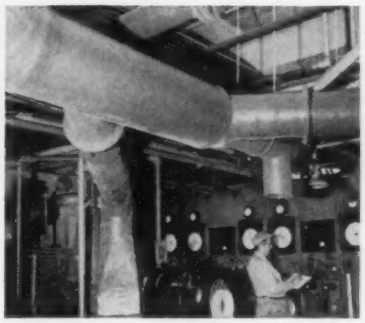
Hetron® ducts outlast metal

Perhaps you've been thinking of Hetron mainly as a *fire-retardant* polyester material.

It's true you get outstanding fire retardance with Hetron. But don't overlook its *corrosion resistance*, which is equally impressive in equipment such as this glass-reinforced ductwork manufactured by duVerre, Inc.

Venting corrosive fumes from a chemical reactor, aluminum ducts failed in 11 months. Ducts made of Hetron 92 replaced them—and have gone 17 months without a sign of deterioration.

In another plant, Hetron 92 replaces rubber-lined steel ductwork which lasted

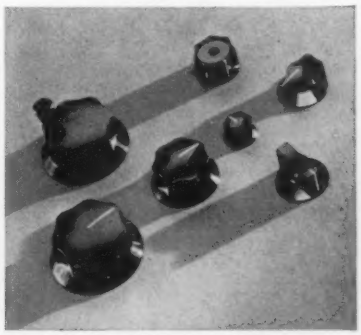


duVerre, Inc.

less than a year under the corrosive bite of wet chlorine. The Hetron ductwork, in service four years, has required no maintenance and is as sound as the day it was installed.

Because it is self-extinguishing, you can safely specify Hetron in many places where a conventional polyester won't do. Fire retardance is *inherent*—does not depend on additives that might dilute corrosion resistance.

Are you taking full advantage of Hetron's unique qualities? A check mark on the coupon will bring you an illustrated bulletin outlining properties and uses of the versatile Hetron resin family.



Ready-tooled knobs

Why tool up for a standard item like a control knob, when you can buy general-purpose knobs like these—probably at a good saving?

Many custom molders can supply knobs in Durez phenolic, from stock tooling, to fit most standard mountings. You can have them hot-stamped with numbers or characters; equipped with special motifs.

Styled as a family, they blend smoothly with modern equipment lines; wipe clean without dulling; and stand up to heat, dampness, and corrosive atmospheres. For further information, consult your molder.

For more information on Durez materials mentioned above, check here:

- ☐ Diallyl phthalate, Durez 16694
- ☐ Hetron polyester resins (bulletin)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

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PLASTICS DIVISION

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Circle 446 on Page 19

It's a Life Saver

because this sensitive

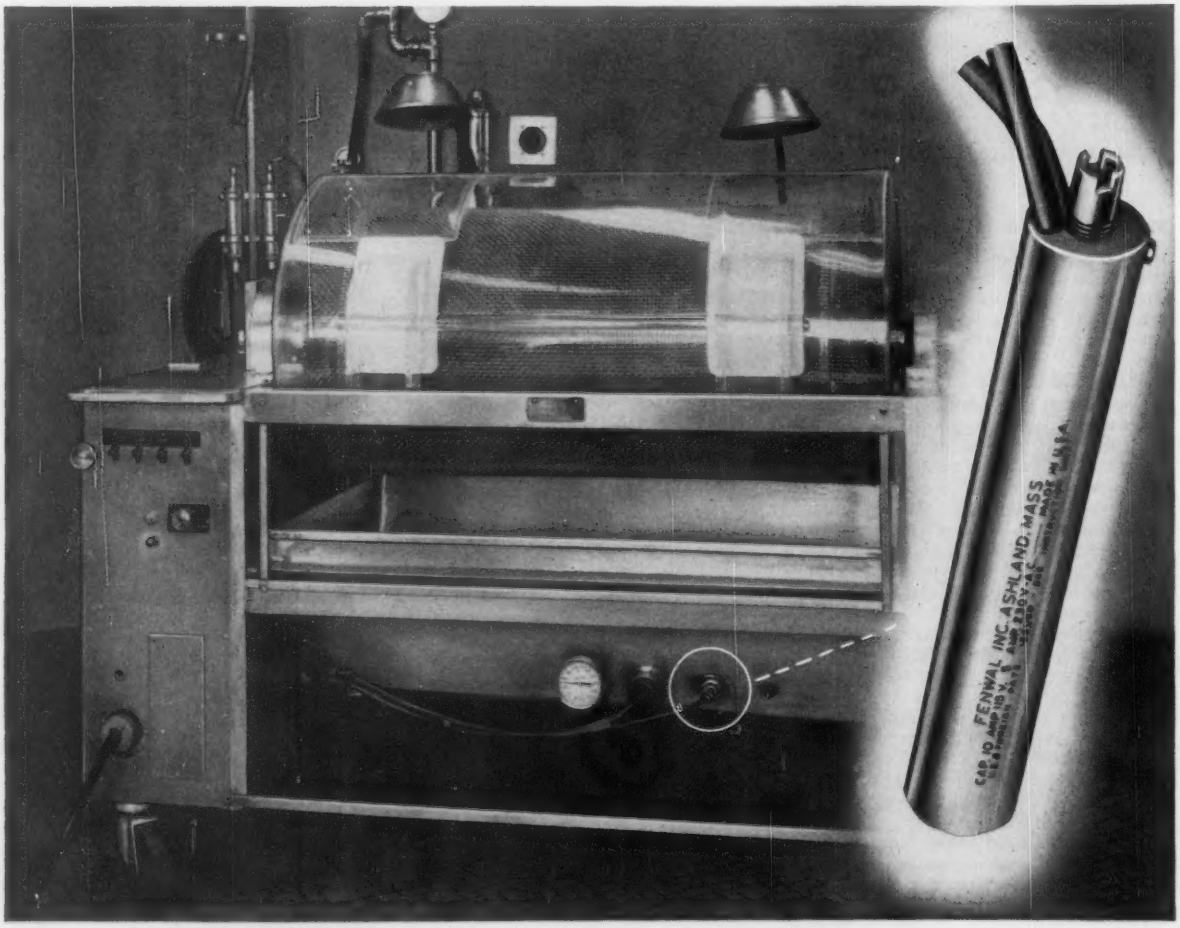
Fenwal THERMOSWITCH® unit controls temperature precisely

Where precise control is necessary, customers have been relying on Fenwal THERMOSWITCH Temperature Controls for years. That's because Fenwal THERMOSWITCH units are extremely sensitive and they last. Consistently they provide one half million cycles or more of precision temperature control. *You get reliability!*

The entire shell is the sensing element of THERMOSWITCH units, giving more heat responsive area and faster reaction to temperature change. This, plus a design based on differential expansion of metals, gives control in fractions of degrees. *You get precision control!*

Fenwal THERMOSWITCH units can help your equipment run faster, require less maintenance, and be more flexible. For information on the model best for your application, write to Fenwal Incorporated, 1911 Pleasant Street, Ashland, Massachusetts, and we'll send you our catalog MC-135 or a sales engineer, whichever you want.

This is our series 17000 in an artificial kidney. This medical equipment has been instrumental in saving the lives of many people suffering from uremic poisoning. Each time the patient's blood passes through the artificial kidney, more poison is filtered out. The Fenwal THERMOSWITCH unit controls the rinsing bath so that blood returns to the patient at body temperature.



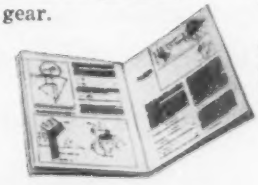
Fenwal CONTROLS TEMPERATURE . . . PRECISELY

★ Useful though uncommon

★ Easy to cut

Tapered gears, although not commonly used, offer a number of advantages when you have a design problem requiring an angular relationship between gear shafts. Production is no problem because, with the proper fixtures, tapered gears can be cut rapidly and economically on a Fellows Gear Shaper.

The tapered gear is simply one whose axis is at an angle to that of the conventional spur or helical gear with which it meshes. If the two axes are at right angles, the "tapered" gear becomes a face gear. If the axes are parallel, it is an ordinary cylindrical gear.



As a result of the use of tapered gears in an aircraft engine, an article giving basic formulae and design considerations was written by a Fellows engineer and published in 1948. Increased interest in this type of gear has since resulted in a number of other applications in machine tools, marine drives, speed reducers and missile projectors.

Because of this increased interest, reprints of the article, "Designing Tapered Gears," are being made available. If you would like a copy, simply write to our main plant in Springfield, Vermont.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
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150 West Pleasant Ave., Maywood, N. J.
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THE PRECISION LINE

Fellows *Gear Production Equipment*

Circle 448 on Page 19

PYRAMIDING DESIGN TALENT

Thin sections, holes, bosses, metal savers, odd shapes all produced in a split second—from molten metal. No other process can compete with this for eye appeal or low cost.

with MADISON-KIPP zinc and aluminum die castings

When product designers send preliminary drawings for critical review by the seasoned Madison-Kipp mechanics, it has often proved to be the decisive factor in the ultimate design of the component parts.

The original designer thoroughly understands the function of his product. We thoroughly understand die casting and machining problems. Combining the two skills at an early period of development is logical and valuable.

Our customers of long standing always utilize this system which virtually pyramids design talent for successful high production manufacturing.

Please clip this ad as a reminder to contact us when you have die casting requirements.

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. . . performance beyond the usual . . .

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Fulfillment of unusual requirement combinations is a specialty at Rollway. Your selection of exactly the right precision radial cylindrical roller bearing is assured by:

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- **Crowned rollers**
- **Modification of any factor to meet your application**

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To further implement your choice, the Rollway Catalog and Engineering Data Book contains the first listing, by any manufacturer, of the thrust capacities of cylindrical radial roller bearings.

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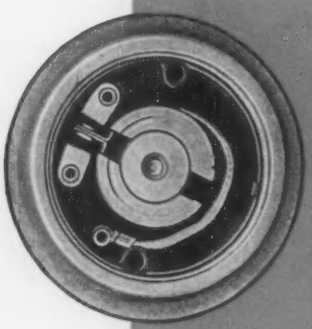
Circle 450 on Page 19

NEW Franklineered® INSTANT-REVERSING MOTORS

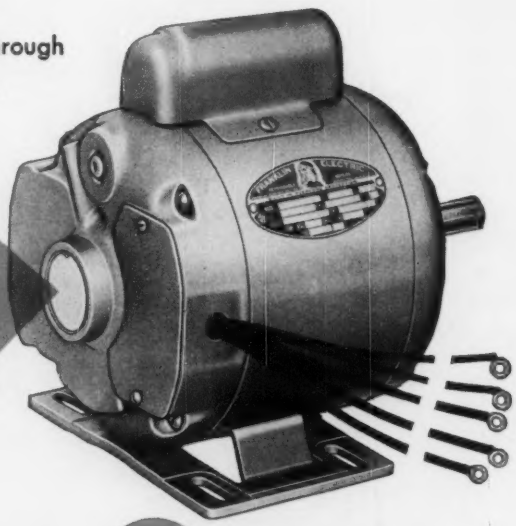
FOR YOUR PRODUCT

. . . Franklin Motors with INST-O-VERSE® apply full power for instant reversing in response to manual or automatic signal.

1/6 H.P. through **1 H.P.**



PATENT-PROTECTED INST-O-VERSE DEVICE



INST-O-VERSE

patent-protected device employs radically new principle. Motor reversal is instant due to independence from relays or delaying mechanical contact with centrifugal switch. Silver contacts on shaft-riding, low-friction nylon "shoes" are automatically preset for reversal with each rotation change. Superior longevity over conventional mechanisms results because INST-O-VERSE does not interrupt a circuit and is not subject to contact arcing. The device is completely protected from dirt or damage in the covered end bell of the motor.

EXAMINE INST-O-VERSE MOTORS IN BOOTHS 484-486 AT THE DESIGN SHOW

INSTANTLY UTILIZES FULL TORQUE CAPACITY OF MOTOR FOR REVERSING ROTATION

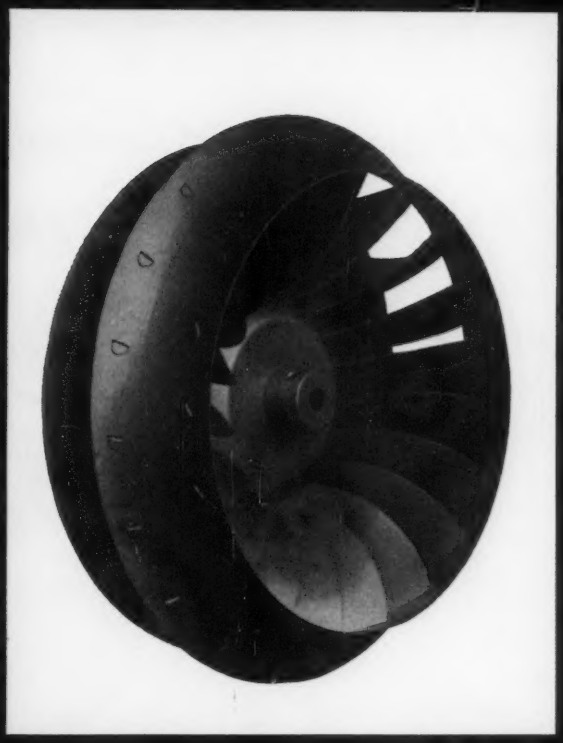
- AVAILABLE IN 1 PH., 1725 R.P.M., 115 OR 230 V., 1/6 THROUGH 1 H.P., SLEEVE OR BALL BEARING MOTORS.
- NEMA FRAME, OR APPLICATION-ENGINEERED MOUNTINGS.
- REVERSING ACTION OF 1-PHASE FRANKLIN INST-O-VERSE MOTORS IS EQUAL TO CONVENTIONAL THREE-PHASE REVERSING MOTORS.
- INST-O-VERSE ENABLES USE OF 1-PHASE INSTEAD OF 3-PHASE MOTORS FOR CUTTING COSTS.

Franklin Electric Co., Inc.

345 EAST SPRING STREET • BLUFFTON, INDIANA

Write for your copy of "INST-O-VERSE MOTORS."

Circle 451 on Page 19



TORRINGTON CRACKS THE NOISE PROBLEM The squeeze toward compactness in room air conditioners has forced the decibel level up to the point that *noise is now the No. 1 problem.* ❙ In anticipation of this trend, two years ago Torrington's air impeller laboratories went to work on "noise." ❙ The result is the revolutionary Torrington H Wheel—one of the most important breakthroughs in air conditioning history. ❙ In one room air conditioner application test the H Wheel reduced the noise level from 63 to 53 decibels; and it was less than *one half as loud.* ❙ Torrington's engineering department is now offering samples of the H-Series Wheel for evaluation in your new product development program.

THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

1/2

Circle 452 on Page 19

Give your design the advantages of

SYNCHRON® TIMING MOTORS

ADAPT- DEPEND- ability

Adaptability

Power-packed SYNCHRON Timing Motors are midget-sized to fit extremely close places. Adaptable to powering timing machines, action signs, recording thermometers, switches, heating and air conditioning devices.

Dependability

SYNCHRON Timing Motors pull up to 20 in. oz. at 1 r.p.m.; operate efficiently at temperatures from —40°F. to +140°F. Each motor must pass 51 inspections and a grueling test under power before shipment.

UL and CSA approvals

Every construction feature performance proven!

1 PATENTED TWO-PIECE FIELD STRUCTURE having wide and narrow poles, with rotor that rotates between inner and outer field poles. The inner and outer poles are properly shaded with heavy, continuous copper rings to assure maximum starting and running torque.

2 DOUBLE BEARINGS in reduction train on rotor shaft assure smooth operation.

3 ALUMINUM ROTOR RING SUPPORT.

4 PATENTED, HARDENED STEEL ROTOR RING.

5 OIL STORAGE RESERVOIR with patented oil feed to bearings.

6 HEAVY BRASS ROTOR COVER.

7 DOUBLE BEARINGS ON OUTPUT SHAFT.

8 GEAR CASE SEALED against oil leakage to permit mounting in any position.

9 FOUR CONVENIENT MOUNTING HOLES.

10 BRASS GEARS.

11 STEEL PINIONS. Note: Brass against steel assures longer life.

12 BAKELITE GEAR for quiet operation.

STANDARD TIMING MOTOR (8 IN. OZ.)
Compactly built to space saving dimensions, with rotor and coil packed in a sturdy hand - sized case. Used in timing devices and controls of all types. Guaranteed torque 8 in. oz. at 1 r.p.m.

HI-TORQUE TIMING MOTOR (20 IN. OZ.)
There's big power packed into this versatile timing motor. One year guarantee. Dependable, accurate, trouble-free. Guaranteed torque 20 in. oz. at 1 r.p.m.

SLO-MOTION SYNCHRON (1 R.P.H.)
A new timing motor developed especially for slow motion jobs. Guaranteed 20 in. oz. at 1 r.p.h. (1/60 r.p.m.)

HANSEN CLOCK MOVEMENTS
For standard and office clocks, sign clocks, novelty clocks, and clocks of all kinds up to 26" in diameter under glass. Precision power with a Synchron timing motor.

HANSEN MAGNA-TORC DC MOTOR
Designed for aircraft instruments and radio controls. Armed Forces applications have proved its top performance worldwide under all operating conditions. Easily adapted to commercial uses.

"Write for Synchron Catalog or See It In Sweet's".

SYNCHRON®

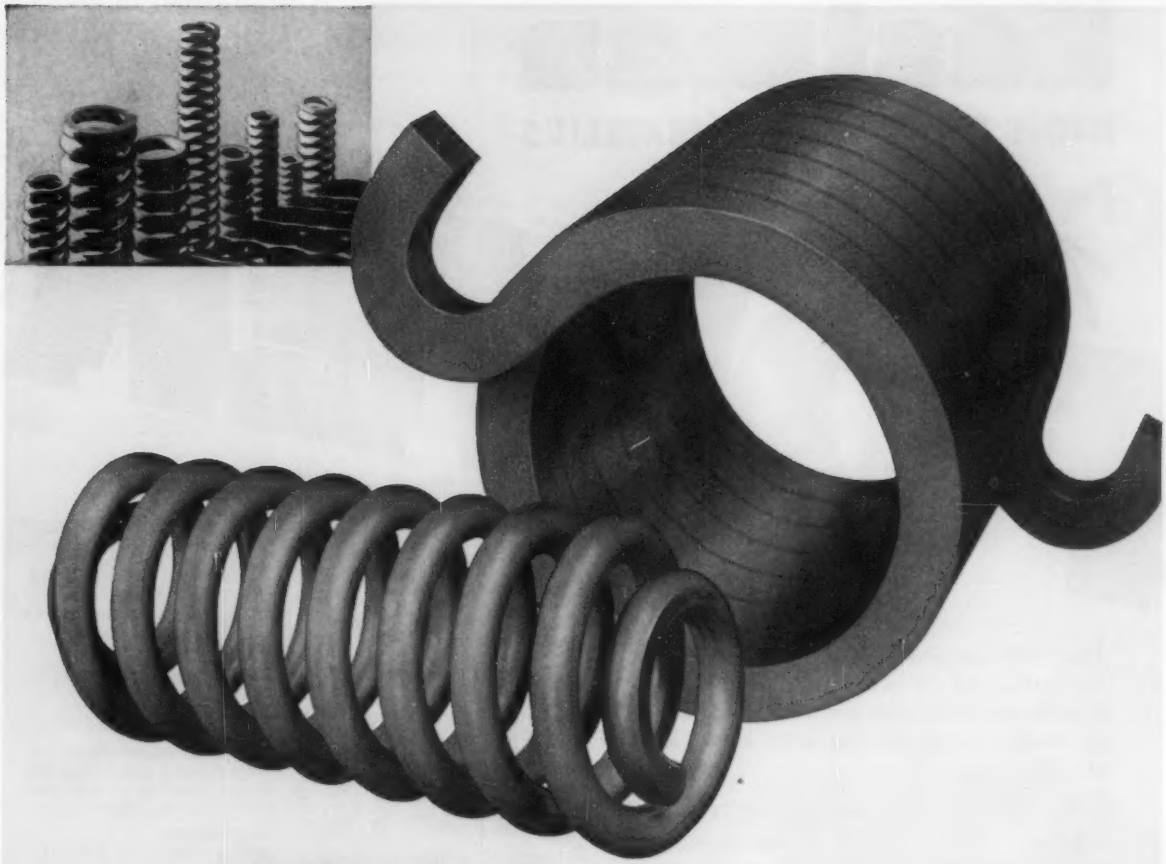
"Workhorse of the industry"
synchronous motors, timing machines, clock movements, magnatorc DC motors

HANSEN MFG. CO., INC.
OUR 50TH YEAR

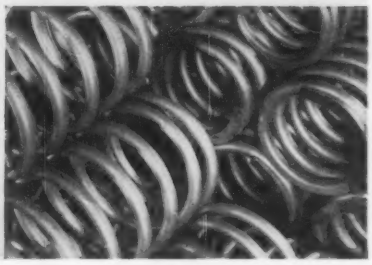
Princeton 12, Indiana

FOR FULL INFORMATION CALL OR WRITE TODAY

HANSEN REPRESENTATIVES: The Fromm Co., 5150 W. Madison St., Chicago, Ill.; Winslow Electric Co., New York, N.Y., Chester, Conn., Philadelphia, Cleveland; Electric Motor Engineering, Inc., Los Angeles WEBSTER 3-7591 and Oakland, Calif.; H. C. Johnson Agencies, Inc., Rochester, Buffalo, Syracuse, Binghamton and Schenectady, New York



CRUCIBLE FATIGUE-RESISTANT SPRINGS



"made stronger to last longer"

Crucible *fatigue-resistant* springs have far greater durability than ordinary springs. Furthermore, these springs, section for section, can take heavier compressive, tensile or torsional loads than ordinary springs. That's because they're *shot peened.* This process imposes a compressive stress on the spring surfaces that offsets stresses set up in service. It also conditions the surfaces, and eliminates minute stress concentration points which could lead to premature failure in a conventional spring.

Try Crucible *fatigue-resistant springs* for lighter springs of improved design, greater precision and longer service life. For complete details, send for the Crucible "Coil Spring Design" handbook. Ask a Crucible spring specialist to call, too. Write: *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE **HEAVY-DUTY COIL SPRINGS**

Circle 454 on Page 19

Eastman

HIGH PRESSURE ASSEMBLIES

for

Responsive POWER

INSTANT response means extra POWER. Improving the "Power-Performance Ratio" of your equipment may mean an extra bucket per minute, extra tons per hour, extra loads per day.

With the increasing emphasis on POWER, it pays to safeguard the most important link in your hydraulic system with Eastman *High Pressure* Hose and Tube Assemblies.

Eastman Coupling Design gives you maximum orifice, consistent with essential safety and strength, to provide "trigger-response" through unrestricted flow from pump to point of work—plus prompt return.

BENT TUBING TO YOUR SPECIFICATIONS

Eastman's modern, hydraulically-controlled tube bending equipment provides bent tubing to your precise specifications—made with flared or beaded ends for your required fittings. Quality workmanship assures satisfactory performance. Mass production economies assure competitive quotations.

For positive power delivery and efficiency throughout your hydraulic system—plus appearance and sales appeal—it pays to specify Eastman High Pressure Hose and Tube Assemblies for your original equipment.

PERMANENTLY ATTACHED MALE (MPTF)
America's most popular OEM Coupling for 1, 2, and 3 wire braid rubber cover hose, and 4 spiral wire extra high pressure hose.
Sizes: ⅜" thru 3".
Working Pressure: 375-5000 p.s.i.
PERMANENTLY ATTACHED SWIVEL FEMALE
Eastman permanently attached couplings give you a bond stronger than the hose itself! For 1, 2 and 3 wire braid rubber cover hose.
Sizes: ⅜" thru 2".
Working Pressure: 375-5000 p.s.i.
PERMANENTLY ATTACHED FLANGE HEAD COUPLINGS
A no-thread, no-leak "O" ring connection, with split flange and insert available in angles from 0°-90°, for 1 and 2 wire braid rubber cover hose.
Sizes: ¼" thru 2".
Working Pressure: 375-5000 p.s.i.
INTER-LOCK® CLAMP COUPLINGS
Exclusive Combination: Clamp-type coupling with "Inter-Lock" feature and blowout-proof split flange for 1 and 2 wire braid rubber cover hose.
Sizes: ¼" thru 2".
Working Pressure: 375-5000 p.s.i.
2-PIECE REUSABLE SWIVEL FEMALE
Increase serviceability of your original equipment with Eastman Reusable Couplings—for rubber and cotton cover hose.
Sizes: ⅜" thru 1¼".
Working Pressure: 375-5000 p.s.i.

Eastman
first in the field

MANUFACTURING COMPANY
Dept. MD-11 • MANITOWOC, WISCONSIN

WRITE FOR HIGH PRESSURE CATALOG!

Get on our mailing list to receive out latest Technical Bulletins, Catalogs and Special Inserts.

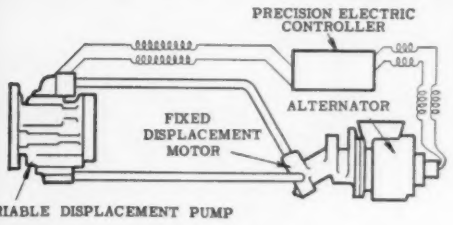
Circle 455 on Page 19

New VICKERS **building block** concept applied to

CONSTANT SPEED DRIVES

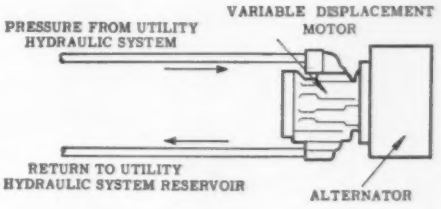
for 400 cycle A.C. electrical systems

1. Unlimited Versatility
2. High Efficiency
3. Fast Delivery
4. Low Cost



Frequency control ± 0.1%. Uses electronic frequency controller to regulate pump displacement. System pressure is function of load.

Frequency control ±0.25%. Uses load sensitive system to match infinitely variable electrical load. System pressure is constant, flow demand is load dependent.



• Using this "building block" construction, Vickers Constant Speed Drives are assembled to exact requirements from the abundance of Vickers standard and proven components. Practically any characteristics you need can be quickly adapted to the existing Vickers product mix. These include:

FREQUENCY CONTROL

± 3% with hydraulic control
± 0.1% with electronic control (or better if desired)

VERSATILITY

1 to 75 hp with standard hardware
Flexibility of package shape and location

HIGH EFFICIENCY

Volumetric efficiency of either pumps or hydraulic motors is 96% at 3000 psi. This together with optimum matching of components results in very high system overall efficiency.

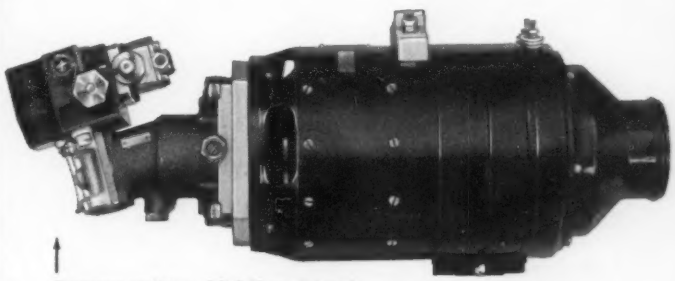
MINIMUM WEIGHT

Significant optimization engineering can be applied to your system design considerations from similar Vickers application experience.

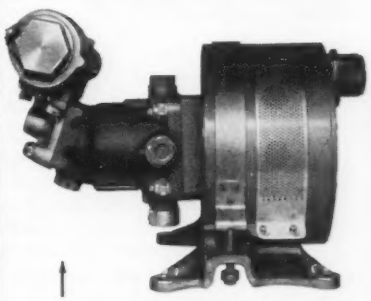
OVERLOAD CAPACITY

Depending upon system requirements, overload capacity of from 120% to 200% can be provided.

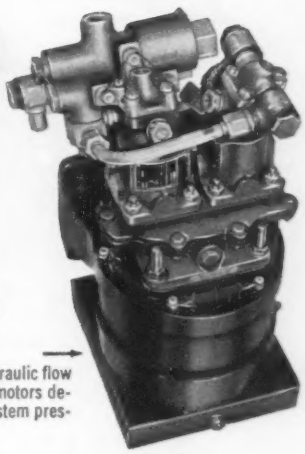
For further information, write for Bulletin SE-100.



Frequency control ± 0.1%. Uses electronic frequency signal to trim hydraulic flow control. System pressure is constant.



Frequency control ± 3%. Uses hydraulic flow control only. System pressure is constant.



Frequency control ± 3%. Uses hydraulic flow control to supply single or dual motors depending upon load variations. System pressure is constant.

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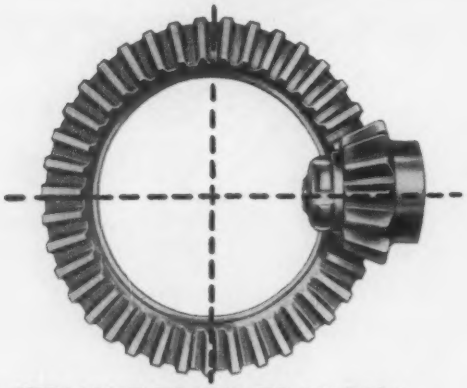
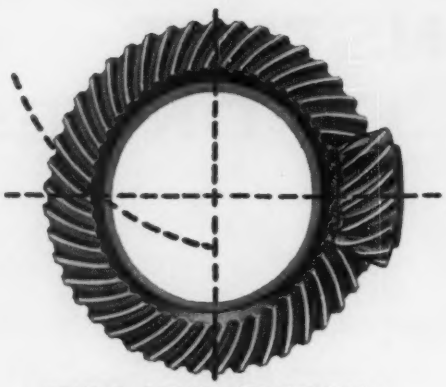
8119

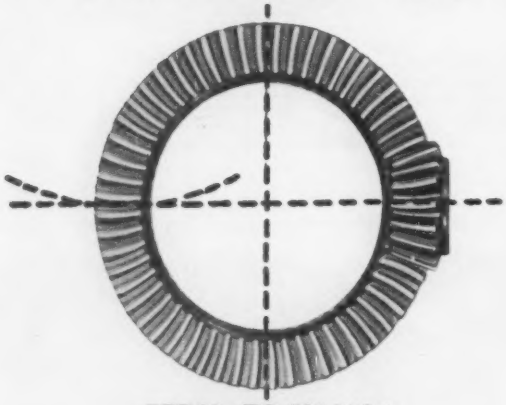
DO YOU KNOW YOUR BEVEL GEARS?



STRAIGHT TOOTH (TO 98″ DIA.)



SPIRAL BEVEL (TO 72″ DIA.)



ZEROL (TO 72″ DIA.)

HYPOID (TO 48″ DIA.)

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Send for our 72 page "Gear Book" G-127. Please use your Business Letterhead when requesting a copy.

Phillie Gear is equipped with the "know-how", the manpower, and latest facilities to manufacture the entire family of Bevel Gearing—sizes and capacities range from the very small to the most massive sizes obtainable. Ultra Precision ground tooth Spiral Bevel Gears are available up to 23″ diameter.

All types and sizes of gears produced by "Phillie" are made to the highest standards of Engineering skill and exactitude—they are the culmination of over 65 years' experience, and are produced on the very latest machines by skilled craftsmen—In a nutshell, Phillie Gear offers, not only the finest gears obtainable, but prompt and courteous service as well.

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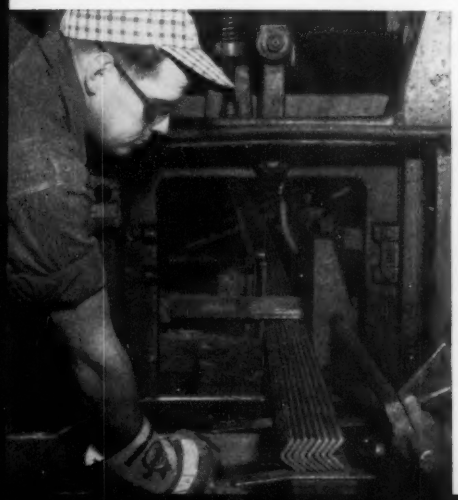
STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS

This is a picture of teamwork. C. G. Merker, U. S. Steel Metallurgist, discusses this cost-saving production change with Dick Sprucebank, Grating Shop Foreman, and Mr. P. H. Rawlins, Division Purchasing Agent.

Stair tread nose plate made in one operation from steel already rolled to shape

One operation – sawing – completed this nose plate made from a special angle section rolled with a raised tread on the top side. Sawing 8 to 10 bars at a time speeds up operations, saves time and money.



Blaw Knox Company, Pittsburgh, makes thousands of open grate stair treads yearly. The nose plate was previously fabricated in such a way that excessive scrap losses and high costs were often incurred.

To solve this problem, U. S. Steel suggested a special angle section with a raised tread rolled on the top side. This eliminated shearing and forming operations, and the resulting scrap loss. The nose pieces could be sawed 8 or 10 bars at a time from 20-foot lengths of steel. The result was substantial savings in cost.

USS Special Sections can be made in many forms so that mass-produced parts can be cut to length as required and processed to finished parts by simplified fabrication. Frequently, this method will substantially reduce costs and result in improved parts. Why not write for complete information? United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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USS United States Steel

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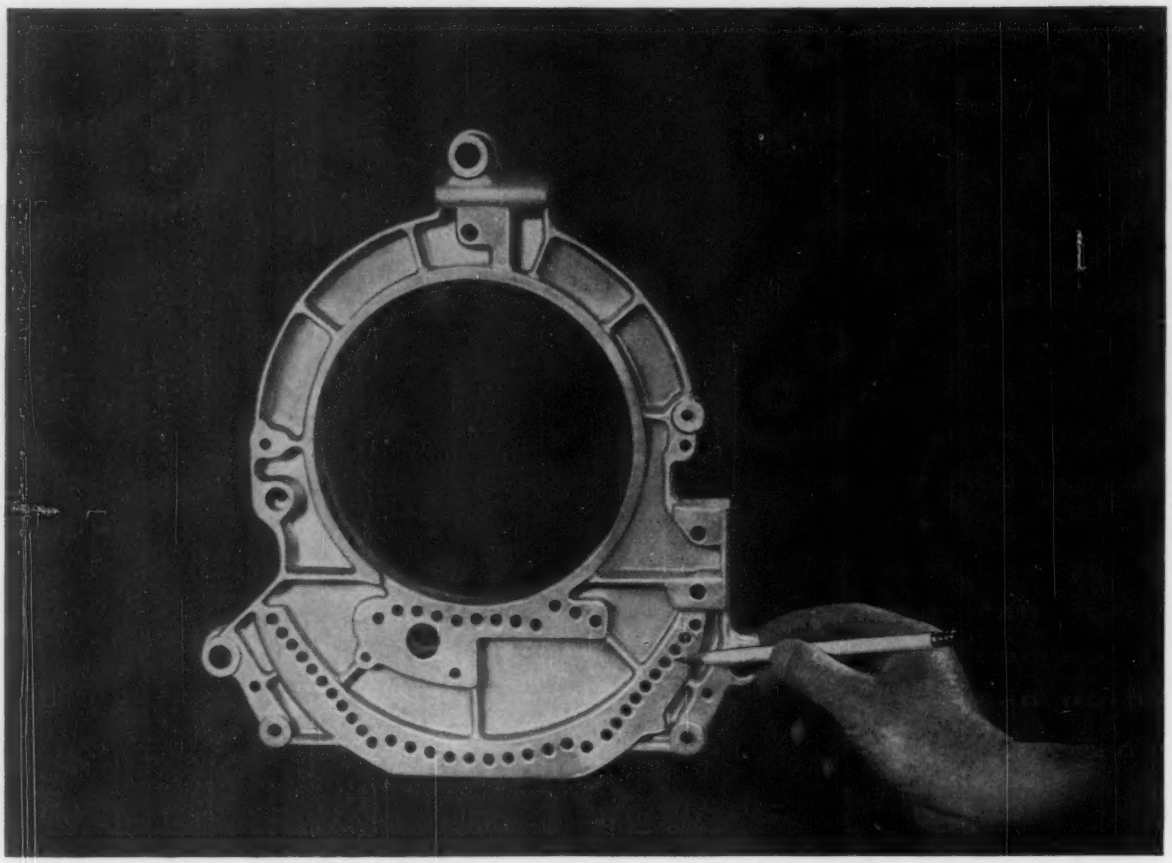

The WHOLE Story Of Die Casting Savings

These close tolerance holes could have cost more than the part itself. Actually, *they cost practically nothing!* Parker-engineered die casting makes the difference. By means of precision coring, the holes are cast to exact diameter and location . . . a bonus in the low unit cost of producing the complete part. Just think of the savings compared with other production methods requiring finish machining.

The creative engineering approach that made these savings possible has been the hallmark of Parker service since 1906. It is the plus factor that is never figured into a Parker estimate. If you are a Parker customer, you know this is so. If you are not, you can profitably prove it to yourself by consulting the nearest Parker sales engineer on your next component part requirement.

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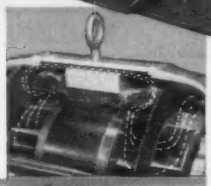
PARKER

high pressure die castings in ALUMINUM • ZINC POWDERED METAL PARTS

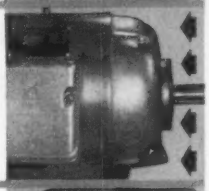
Circle 459 on Page 19

NEW R&M Re-Rated Series 254U All-Weather Motors

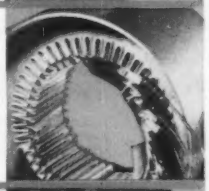
"straight through" dual-sweep ventilation eliminates "hot spots"



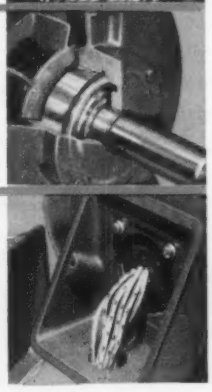
full height end head protection



Mylar insulation increases motor life*



bearings easily inspected by removing cover plate



permanently numbered leads simplify installation and maintenance

*DuPont registered trademark.

Premium Performance

. . . at standard motor prices

R&M Series 254U Motors help pay their own way from the minute you flip the switch! They stoutly resist any hostile environment—moisture, dirt, heat, acid or alkaline fumes—and so live longer. They have push-pull ventilation that won't let dirt settle and keeps motor internally cool—and so perform with full, brisk efficiency. Their oversize bearings are quick and easy to inspect and relubricate—so your maintenance costs dwindle.

This long, trouble-free, vigorous motor life is what R&M means by "Premium Performance"—an extra reward in service and savings every R&M motor offers. These and other big, money-saving advantages shown at left cost no more . . . R&M motors carry standard motor prices!

Write today for R&M Bulletin 520-MD!

Robbins & Myers build motors from 1/200 to 200 horsepower

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

Circle 460 on Page 19

Solve it

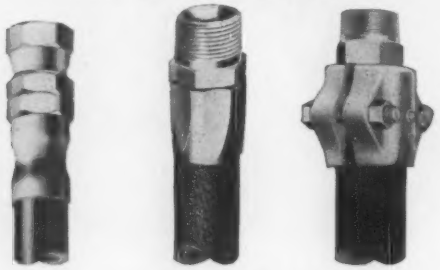
WITH

WEATHERHEAD

Hose assemblies, hose and hose ends, both permanently attached and reusable to meet any O.E.M. requirement. That's what Weatherhead offers you. Permits unlimited design possibilities.

HOSE ASSEMBLIES

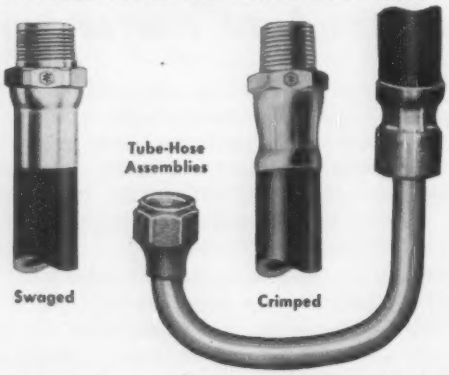
WITH REUSABLE HOSE ENDS



Steel "D" Style H-69 Clamp-Type

HOSE ASSEMBLIES

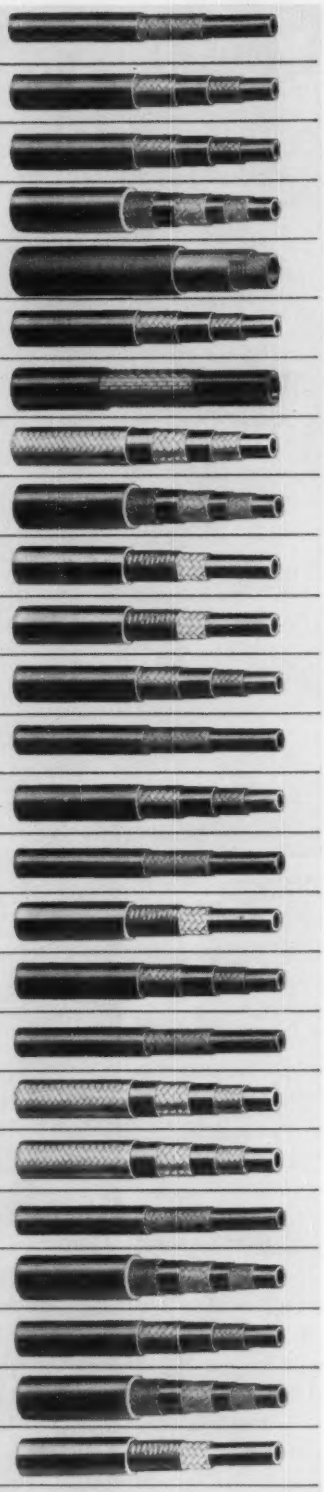
WITH PERMANENTLY ATTACHED HOSE ENDS



Swaged Crimped

Weatherhead has perfected swaging and crimping machines which permit O.E.M. production of quality permanent hose assemblies at reduced cost. Write for complete information.

BULK HOSE FROM 1/8" TO 2 1/2" I. D., PRESSURES TO 10,000 P.S.I.



and many others

WEATHERHEAD

THE WEATHERHEAD CO., FORT WAYNE DIVISION

Dept. AB-11, 128 West Washington Blvd., Fort Wayne, Indiana

In Canada: The Weatherhead Co., Ltd., St. Thomas, Ontario

MACHINE DESIGN
November 27, 1958

The Pro

SOMERSET Maugham tells the story of a young man with an all-consuming desire to become a professional pianist of the first rank. He couldn't bear to live when told that he lacked what it takes to be anything more than a competent amateur: "In art the difference between the amateur and the professional is immeasurable."

In engineering, fortunately, the difference is not so immeasurable. At least, the competent amateur can upgrade his performance to a reasonably professional level.

How plentiful are the pros? History of the demand for engineers suggests the answer. Through depressions, recessions, booms, and wars the demand for the pro never lets up, is never fully satisfied. But the amateurs who stay amateurs really feel the pinch of economic setbacks.

The pro has thoroughly mastered the art, science, and techniques of a particular branch of engineering. To attain such eminence entails discipline, concentration, endless practice, the sacrifice of other interests. The professional musician—as well as the professional ball player—knows this full well.

Are the incentives adequate? To some the satisfaction of doing a high-level professional job is its own reward. But it isn't sensible to count on such built-in incentive. It won't furnish enough pros to meet today's needs.

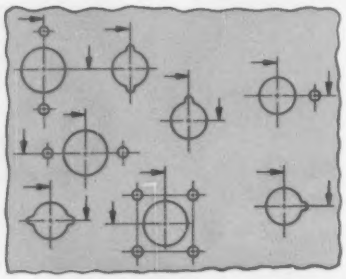
Top management must be prepared to recognize and suitably reward pro-level talent. Eminent professional achievement in the technical field should be worth at least the status accorded successful selling, supervision, or management.

Even with the highest incentives there will never be too many authentic pros.

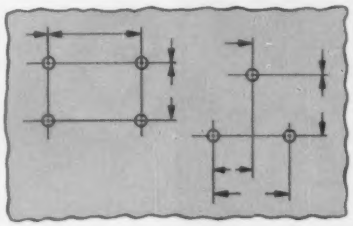
Colin Carmichael

EDITOR

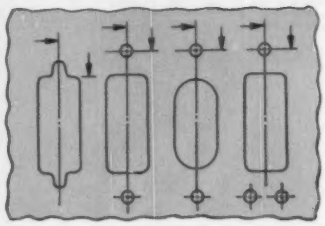
Methods of Locating and Dimensioning Holes



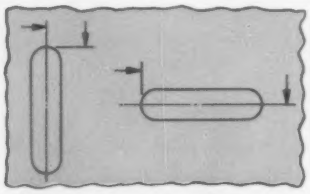
Locate round holes with related holes or slots to center lines of center hole



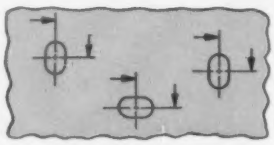
Tie together and locate a group of holes that must match with a similar group on mating parts



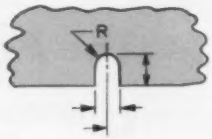
Locate rectangular cutouts and slots with related holes or slots on a common center line



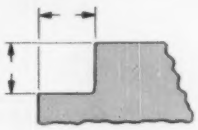
Locate large slots (for other than screw clearance) dimensionally to center lines and one end



Locate screw-clearance slots to center lines to provide a ready check on mounting-screw location



Locate open-end slots to center lines



Dimension corner notches for actual material removed

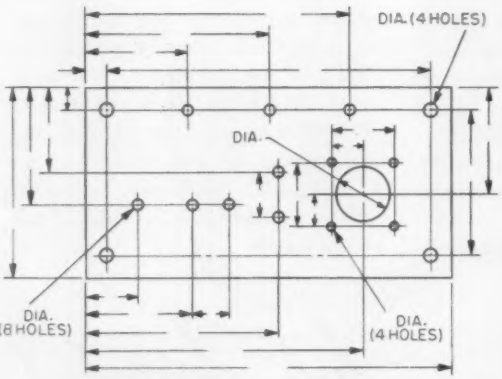


Fig. 1 — Conventional rectangular dimensioning method in which dimensions are measured in parallel sequence from mutually perpendicular base lines

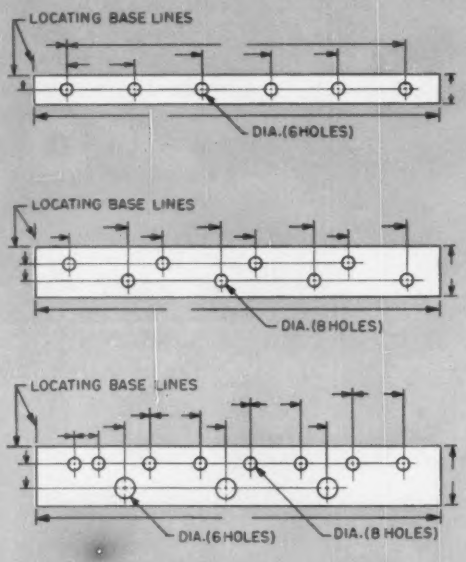


Fig. 2—Typical modified dimensioning practice. A portion of the dimension line and the arrowhead are omitted between the hole center lines and locating base line. Over-all dimensions are shown complete

PRACTICAL DIMENSIONING PRACTICES

By R. E. RUCKSTAHL and G. A. LARSON
Manager, Drawing Office Engineer, Drawing Office
Air Arm Div.
Westinghouse Electric Corp.
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DIMENSIONING practices tailored to the needs of an organization, generally represent a compromise on drawing policy between engineering and manufacturing. However, these practices, while aimed at insuring correct interpretation of drawings by those handling them, should conform to military and commercial standards.

Establishing a general policy for dimensioning is best accomplished by incorporating acceptable company standards into a manual for ready reference. Dimensioning methods shown here form part of a drafting manual whose setup and maintenance are covered in a previous MACHINE DESIGN article.* Although these methods were developed primarily for sheet-metal dimensioning such as in chassis design, they are applicable to many types of layout.

*R. E. Ruckstahl—"The Drafting Manual," MACHINE DESIGN, Vol. 30, No. 21, October 16, 1958, p. 108.

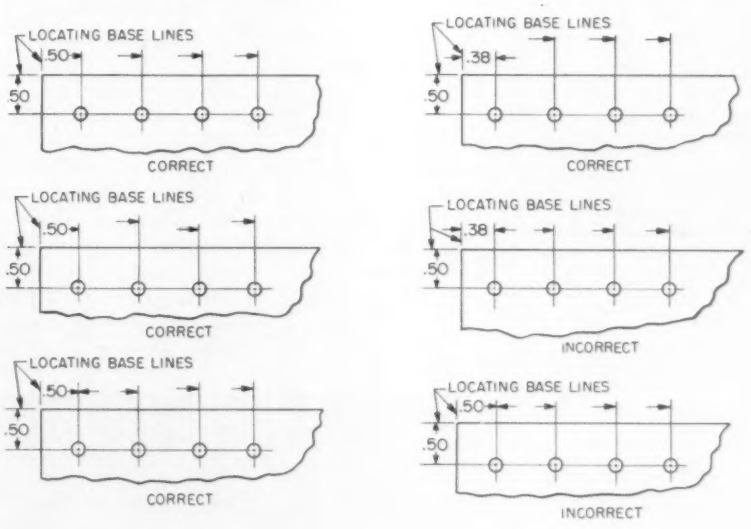


Fig. 3 — Correct and incorrect methods of progressive dimensioning. Progressive dimensions should never follow an over-all dimension because of possible confusion as to location of base line

Properly prepared and applied, a standardized presentation will:

1. Provide a source of ready information on company procedure for experienced draftsmen.
2. Provide a training aid for apprentice draftsmen.
3. Curtail misinterpretation of drawing requirements.
4. Reduce the possibility of producing or passing an unacceptable part.

Progressive Dimensioning: To avoid accumulation of tolerances through chain dimensions, a base line should be established from which the majority of dimensions can originate. Selection of a base line is affected by design requirements and the relationship of components or mating parts. Usually, an edge is given first preference, but a centerline or hole may be used.

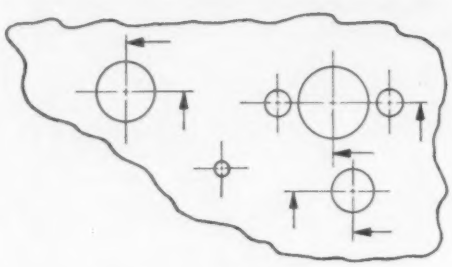


Fig. 4—A portion of a complicated drawing which requires dimensions on the view rather than outside of it as preferred

The preferred method of dimensioning is the conventional method, Fig. 1, which illustrates a functional requirement between the four corner holes of the part. Basically, this method is the rectangular dimensioning system in which distances, location, and sizes of holes are indicated by means of linear dimensions measured in parallel sequence from base lines or from planes perpendicular to each other.

When a large number of dimensions must be indicated by the conventional method, drawing space can be greatly reduced by using a modified form of dimensioning called "progressive dimensioning." Generally, a set of co-ordinate base lines are established by selecting two edges at right angles and are identified by the note "Locating Base Lines." Dimensions are applied by omitting the portion of the dimension line and the arrow head between the dimension and the base line. Over-all dimensions are the exception; they are shown complete, Fig. 2.

One or more complete dimensions may follow in alignment with a progressive dimension. However, a progressive dimension should never follow in alignment with a complete dimension as confusion may result relative to location of the base line, Fig. 3.

Wherever possible, dimensions should be placed outside of the view. In many cases, particularly in complicated drawings, it may be necessary to show dimensions on the view by placing them close to features dimensioned, Fig. 4.

Functional requirements may necessitate use of auxiliary base lines in other sections of the detail

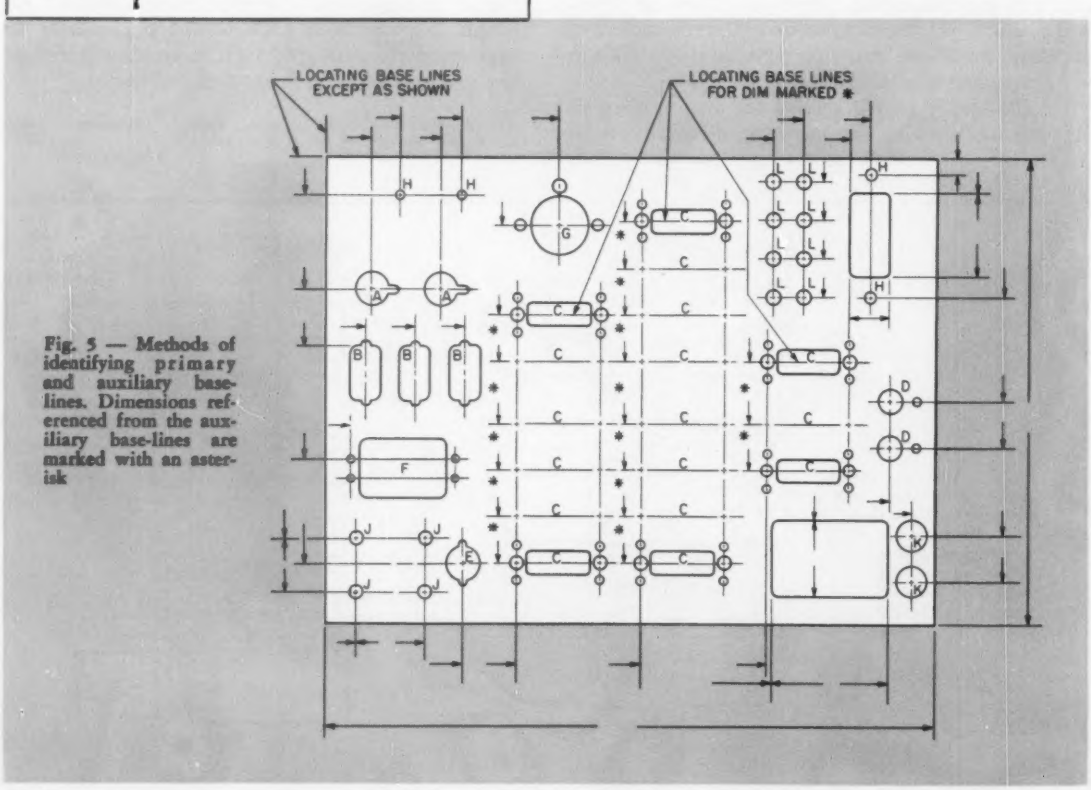
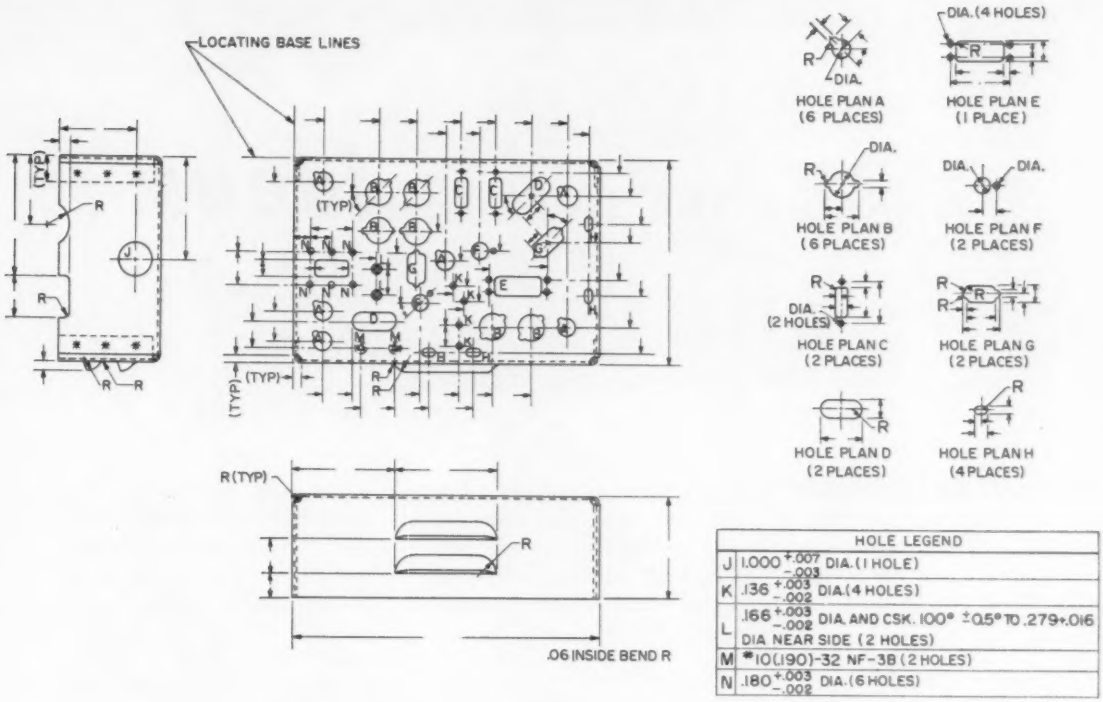


Fig. 5 — Methods of identifying primary and auxiliary base-lines. Dimensions referenced from the auxiliary base-lines are marked with an asterisk



HOLE LEGEND	
J	$1.000^{+.007}_{-.003}$ DIA. (1 HOLE)
K	$.136^{+.003}_{-.002}$ DIA. (4 HOLES)
L	$.166^{+.003}_{-.002}$ DIA. AND CSK. 100° ±0.5° TO .279+.016 DIA. NEAR SIDE (2 HOLES)
M	*10(.190)-32 NF-3B (2 HOLES)
N	$.180^{+.003}_{-.002}$ DIA. (6 HOLES)

Fig. 6—Dimensioning hole patterns. A hole legend and hole plan are arranged outside the detailed plan view which shows only hole location by progressive dimensioning. Angles are shown in the hole plan only when the same pattern appears at the same angle in all locations. Otherwise, hole plans are shown on the horizontal, and the angle is dimensioned on the plan

drawing when applicable dimension space is limited. To further substantiate, each dimension in each group should be symbolized referring back to its common base line. Each auxiliary base line should be referenced with a note *Locating Base Line for Dimension Marked** and the primary base line referenced *Locating Base Line Except as Shown*, Fig. 5.

Dimensioning Hole Patterns: Parts having numerous holes and hole plans may be dimensioned by a legend and plans outside the details, Fig. 6. Individual hole plans can be standardized by showing them on the drawing exactly as they appear on *Recommended Hole Patterns* sheets. Generally, for most complicated detailed parts, when it has been decided to use hole plans, it is advantageous also to use a legend for remaining holes. These should be designated in alphabetical sequence.

All locating dimensions for holes or hole plans are generally referred to the upper left flanged surfaces or outlined edges. A good reason for deviation from this rule is the consideration of how the holes should be located so as to go through the fewest number of bends when figuring the developed location. When this condition exists, reference to the lower right hand corner may be preferable.

Frequently, in the case of slots, mounting holes for tube sockets and connectors, or any other pattern of holes, it is preferable to show positions on an angle. Therefore, the angular dimension must be included as shown in Fig. 6. When the same pattern appears at the same angle in all locations, show the angle in the hole plan. If the same pattern appears in several places but in various angular positions, show the hole plan on the horizontal and indicate the angle on the view. Angles recommended are multiples of 15 and/or 22½ deg from 0 to 180 deg.

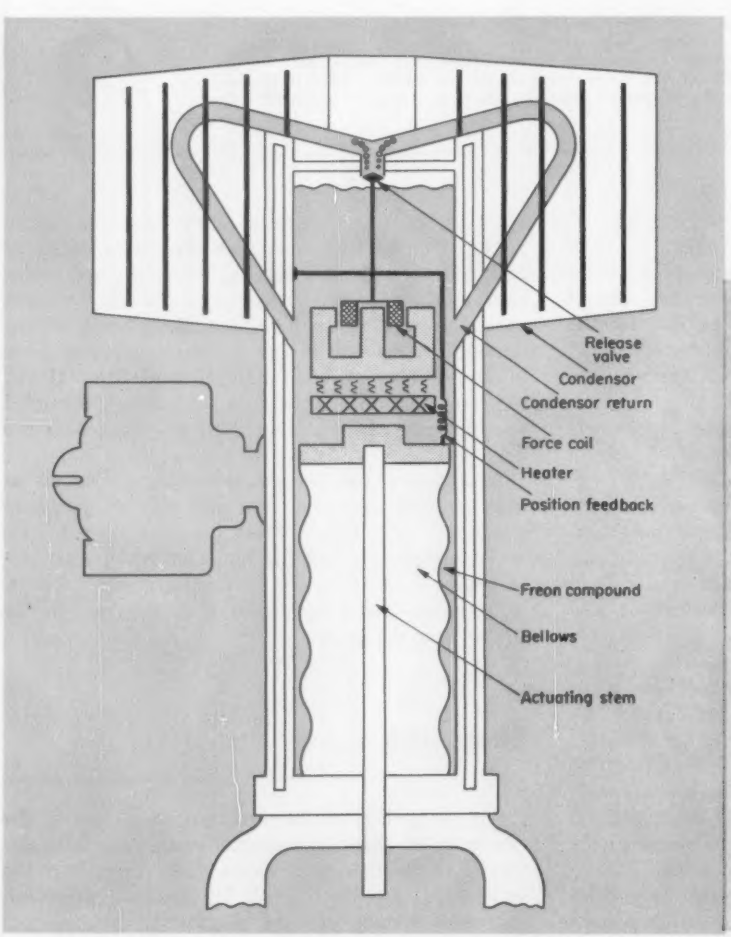
As a general rule, rectangular cutouts with related holes around the cutout are dimensioned as shown in Hole Plan E, Fig. 6. The cutout is located by one set of dimensions and the holes by another set. An exception to this rule, due to functional requirements, is to locate the round holes first, then locate the cutout from the holes.

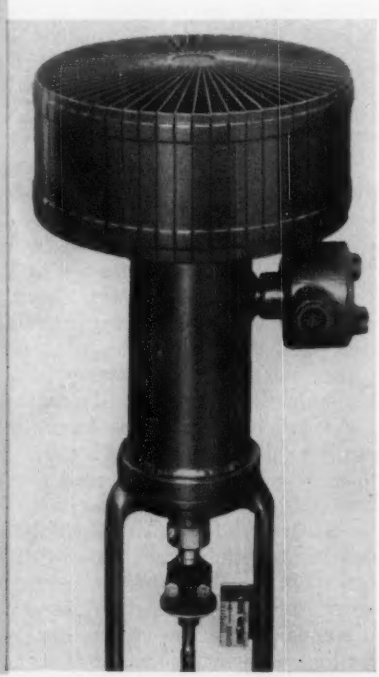
They Say . . .

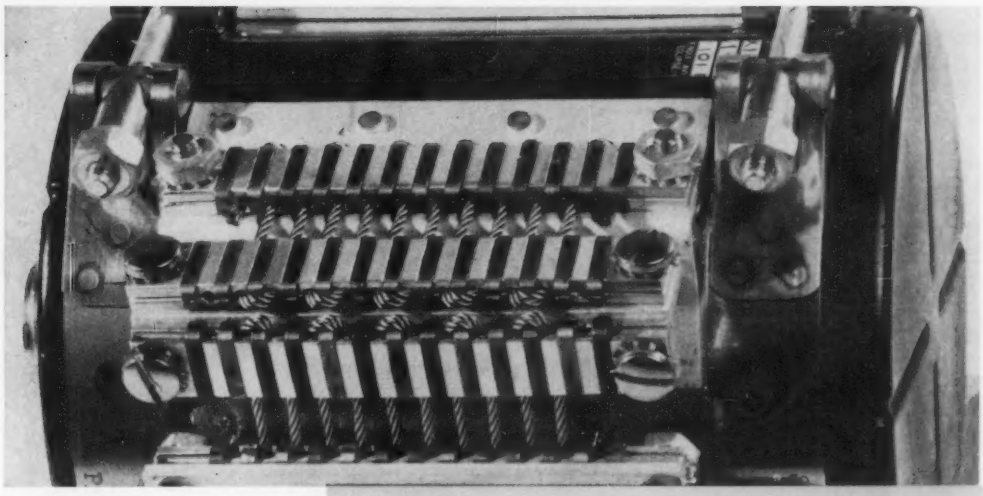
"As engineers fail to communicate to others the character of their professional work, they lose deserved recognition and lessen their opportunity to serve humanity." — Louis R. Howson, *president, American Society of Civil Engineers.*

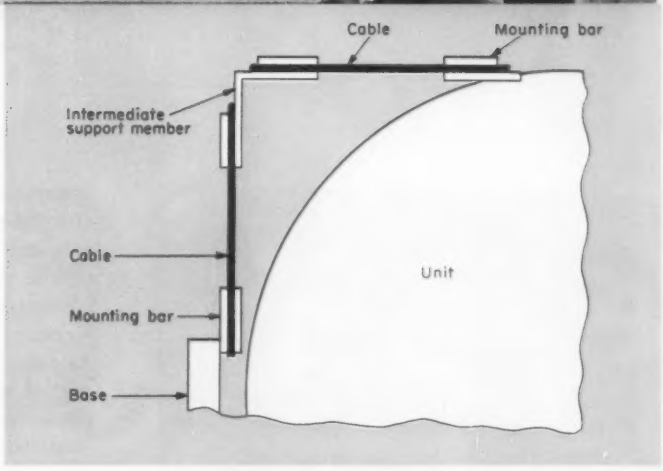
scanning the field for *ideas*

Thermal drive develops linear motion by controlling pressure of Freon vapor in a closed circuit. In the Swartwout Thermo-Drive Actuator, vapor pressure operates a bellows to move the actuating stem. Vapor pressure is produced by constant heating of liquid Freon. Control action is achieved by varying the bleed rate of the Freon vapor into a finned, ambient-exposed condensor. The rate of bleed is controlled by a release valve, operated through an external signal. When the bleed rate is decreased, vapor pressure increases, and the bellows is compressed. Conversely, an increase in the bleed rate permits the bellows to expand.

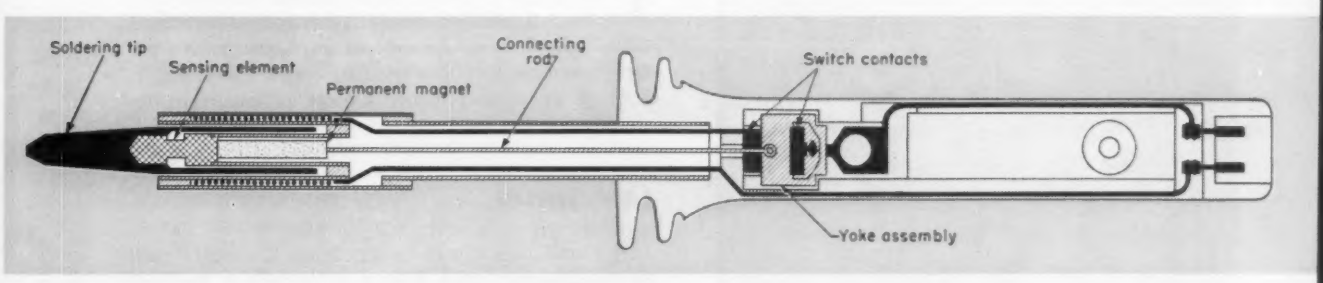




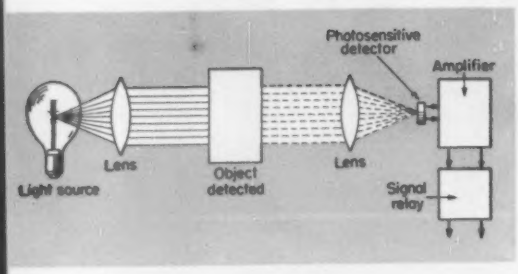




Rubbing wire strands in taut cable supports damp high or low-frequency vibration. In the Finnflex vibration-isolation assembly, the isolated unit is supported by means of multiple cable loops attached to the base frame. Rubbing of the wire strands during cable movement produces a friction-damping action. Variation in damping effect is obtained by changing the cable length, diameter, material, or number of strands.



Magnetic thermostat utilizes demagnetizing effect of elevated temperatures to operate an electric control circuit. In the Weller Magnastat soldering iron, a thermo-magnetic sensing element, which loses its ability to accept magnetism above a critical temperature, acts with a permanent magnet to control the heating of a soldering tip. A rod and yoke assembly connects the magnet to a switch contact, which is held open by a compression spring. When the temperature of the sensing element is below its critical temperature, it is attracted by the magnet and closes the contact, permitting current to flow through the heating element. When the tip and sensing element reach the critical temperature, the sensing element loses its magnetic characteristics and is released by the magnet to open the circuit contacts.



Designing PHOTOELECTRIC

By J. J. LAREW
Specialty Control Dept.
General Electric Co.
Waynesboro, Va.

Instantaneous response to the absence or presence of a light beam makes "electric eyes" ideal solutions to many machine-control problems. These photoelectric controls offer the designer the tremendous advantage of not physically touching parts being measured, counted, inspected, or otherwise sensed. As pointed out here, each element in a photoelectric control system must be carefully selected and applied—including the light source, lenses, light filters, photosensitive detector, amplifier, and control relay.

PHOTOELECTRIC relays offer ideal solutions to many problems in automatic machine control. A photoelectric relay system is composed of a light source, optical parts, photosensitive detector, and an amplifier with an output relay, Fig. 1. Each of the system elements plays an important design role.

Light Sources

A low-voltage incandescent lamp is usually used in combination with a lens to provide a beam of light for operation at a distance, or a concentrated spot of light for scanning near-by objects.

Lamps with short, heavy filaments are better in photoelectric relay systems than lamps designed with long, thin filaments for three reasons. First, the larger thermal inertia of a heavy filament develops less flicker when operating on alternating current. High-speed photoelectric relays respond to even 120-cycle flicker and may buzz or operate erratically if appreciable flicker is present in the light source.

Fig. 1—Photoelectric control unit designed with a heavy-duty output relay. The tubes make up the amplifier and power supply. The operator is setting the light-level adjustment

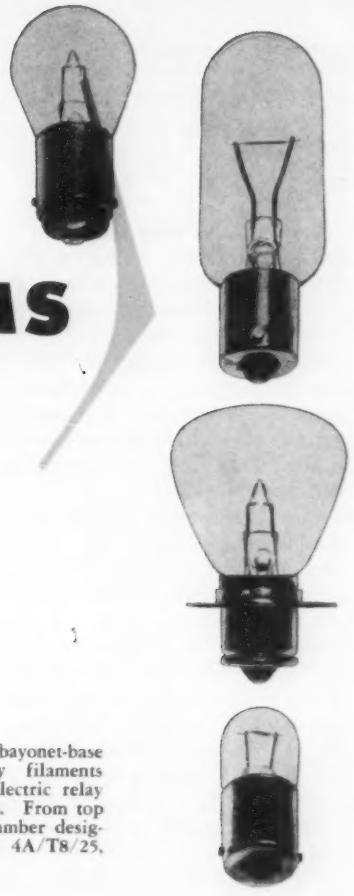


Fig. 2 — Typical bayonet-base lamps with heavy filaments suitable for photoelectric relay system light sources. From top to bottom, lamp number designations are 1608, 4A/T8/25, 1325, and 1489

Second, the heavier filament structure is more resistant to shock and vibration. Third, heavy filaments more nearly approach a point source of light and produce more light intensity at the receiver for a given power dissipation. Short, heavy filaments are used in low-voltage lamps, and automotive type lamps are frequently used. Several typical light-source lamps suitable for photoelectric-relay applications are shown in Fig. 2.

Prefocused lamps and other special optical lamps maintain the shape and location of the filament within close tolerances. The lamp used should be one designed for optical use. Candelabra or "screw-in" type bases are generally not suitable since filament orientation is not constant, and the bulbs may loosen in the presence of vibration.

Maximum light intensity is obtained by using a large lens and higher applied voltages. A lamp with higher candlepower rating may produce little increase in intensity since it may be built with a larger filament operating at the same temperature, resulting in a larger image at the receiver but no increase in intensity. In Fig. 3 is a typical plot of light output and lamp life versus voltage. It is apparent that a great increase in light can be obtained at the expense of lamp life. The type of lamps ordinarily used should be operated considerably below rated voltage to obtain long life.

For other than point light sources, intensity in foot-candles produced at the photosensitive detector is inversely proportional to the square of the distance between the light source and the detector. Distance must be carefully considered in choosing a light source for a particular application. The sensitivity of the photoelectric relay is usually expressed in terms of minimum change in light intensity required for reliable operation.

Bulb blackening will always occur at the "top" of the lamp in its burning position. Blackening will not pose a serious problem unless the light beam is projected vertically upward through the blackened portion of the glass.

Infrared light is generally used where it is desirable to have an invisible light beam. Ultraviolet light is often used to cause fluorescence of some material, the visible light thus produced being used to operate the photoelectric relay.

Infrared transmitting filters, Fig. 4, exclude almost all visible light and enable a standard incandescent lamp to be used as a convenient source of infrared. Where the photosensitive detector is sensitive to both visible and infrared light, an infrared filter will cause some reduction in over-all system sensitivity. This reduction amounts to 40 per cent with the filter in Fig. 4 and a red-sensitive phototube having an S1 response, Fig. 5.

Photosensitive Detectors

Several of the more common photosensitive detectors are shown in Fig. 6. Phototubes or photocells are now available with almost every conceivable shape, size, impedance, and spectral sensitivity. Because of the widely different output signal and impedance levels available, the choice of the photosensitive detector and its amplifier must be closely co-ordinated. Usually the amplifier is suitable for

use with a given class of detectors and a considerable variety of tubes or cells are available within this class.

Photoemissive tubes contain a light-sensitive cathode and an anode within a glass envelope which may be evacuated or contain a small amount of gas. Light striking the cathode causes emission of electrons which are drawn to the anode when a positive voltage is applied, resulting in anode current proportional to light intensity. The spectral-response characteristic is determined by the composition of the light-sensitive coating of the cathode. In Fig. 5 are two typical response curves together with the response curve of an average human eye. One of these tubes is primarily sensitive to blue and ultraviolet light and the other to red and infrared light. Where the application involves simply the making and breaking of a beam of white light, either of the tubes will generally work satisfactorily since white light contains all colors to some degree. In reflected light systems, certain portions of the spectrum will be absorbed to a greater degree than others by the reflecting surface, and one spectral response characteristic will prove to be more suitable than another. Experience has shown that one of the two spectral-response characteristics in Fig. 5 will handle almost any colored-light application.

Photoemissive tubes produce output currents of only a few microamperes. If these tubes are operated well below their ratings, almost unlimited life can be expected. Continuous operation at or above their ratings will result in much shorter life and bad fatigue effects (rapid drop in sensitivity, recovering after period of inactive storage). In spite of the very low output current, the signal level produced by these tubes across a 10-megohm load resistor, for example, will often be sufficient to operate a plate-circuit relay through a single stage of amplification.

Excellent high-frequency response is obtainable with photoemissive tubes, especially the vacuum tubes. They are available in a wide variety of spectral-response characteristics. Their long-term stability, temperature stability, and the extremely low dark current are additional advantages. These must be weighed against their size and high impedance which are sometimes disadvantageous.

Photomultiplier tubes are a special design of the photoemissive tube which produces amplification of minute cathode currents. These tubes have extremely high sensitivity, but this sensitivity is greatly affected by minute changes in supply voltage.

Photoconductive cells have been available for many years. Great strides have been made in developing cells which are smaller, have higher power-handling capability, and cover portions of the spectrum from x-rays to the far infrared or heat radiation. Many new models are being produced each year.

One of the most striking characteristics of these cells is their small size. One manufacturer offers an assembly of 20 lead-sulfide cells on a flat plate

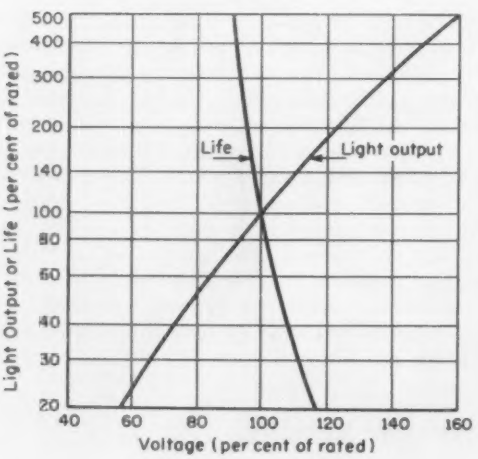


Fig. 3—Plot of lamp life and light output versus applied voltage. A typical lamp may have a rated life of 200 hr at a rated voltage of 6.4 v; life of this lamp can be increased to 2000 hr if operated at 5.2 v

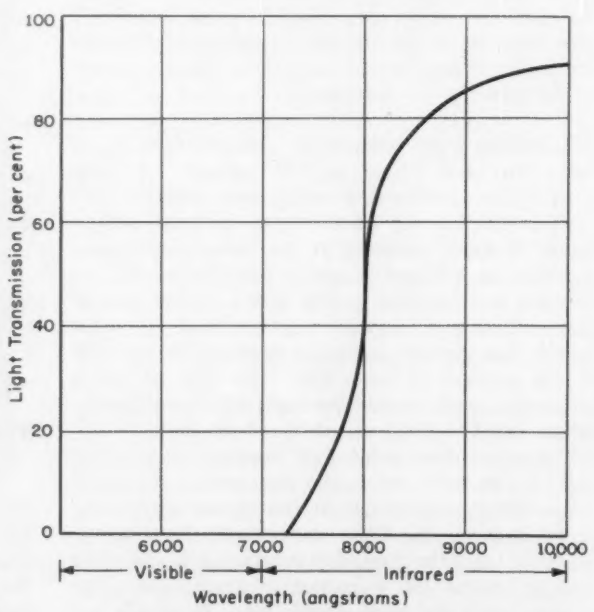


Fig. 4—Spectral transmission curve of a typical infrared filter for photoelectric relay systems

having a length of only ½ in. Their suitability for miniaturization makes photoconductive cells ideally suited for card and tape readers, analog to digital converters, and similar applications. They also make possible extremely small sensing heads for photoelectric relay systems, opening entirely new fields for photoelectric applications.

Power-handling capability of some of these cells has been increased to the point where photocell currrent can be used directly to operate a small magnetic relay. Control units are on the market which contain only a photocell and a relay for operation on 115 v ac. These relays are limited to applications involving 100 per cent light cutoff because of rather large operating differentials in the sensitive relays and the sizable dark current in many cells. The relay pickup and drop-out times depend upon the light level. High light levels result in fast pickup with slow drop-out, and vice versa. The maximum operating rate is limited by the time delay introduced by the cell itself and is generally much slower than that obtainable using photoemissive tubes.

Photovoltaic cells require no external power supply. They generate a dc voltage proportional to the light intensity. These cells have been built into photographic exposure meters for many years. Recently much work has been done to develop cells of this type with a high efficiency of energy conversion for converting sunlight directly to useful amounts of electric power. These are commonly called solar batteries.

Control applications of photovoltaic cells usually involve the use of a contact-making microammeter to amplify the very low power output of the cell.

The cells are extremely stable and have unlimited life. They have been well proven through many years of field usage. They are commonly available with a spectral response which covers most of the visible spectrum. Since a photoelectric relay system of this type usually involves a contact-making instrument, the over-all degree of reliability obtainable depends almost entirely upon the reliability of the instrument and its contacts.

Simple Optical Systems

Basic knowledge of lenses, apertures, filters, and optical techniques will permit effective application of commercially available photoelectric relay systems to obtain a high degree of reliability at low cost.

Lenses are the most commonly used optical tools. Fig. 7 illustrates the use of lenses in combination with a light source and a photosensitive detector. Light rays originating at the small filament go outward in all directions. If a lens is placed at a distance F from the filament, where F is the focal length of the lens, the rays which intercept the lens will be converted into parallel rays which form a beam of light. Rays A and B, which would have otherwise been lost, are redirected toward the phototube holder. The larger the diameter of the lens for a given focal length, the more rays it will in-

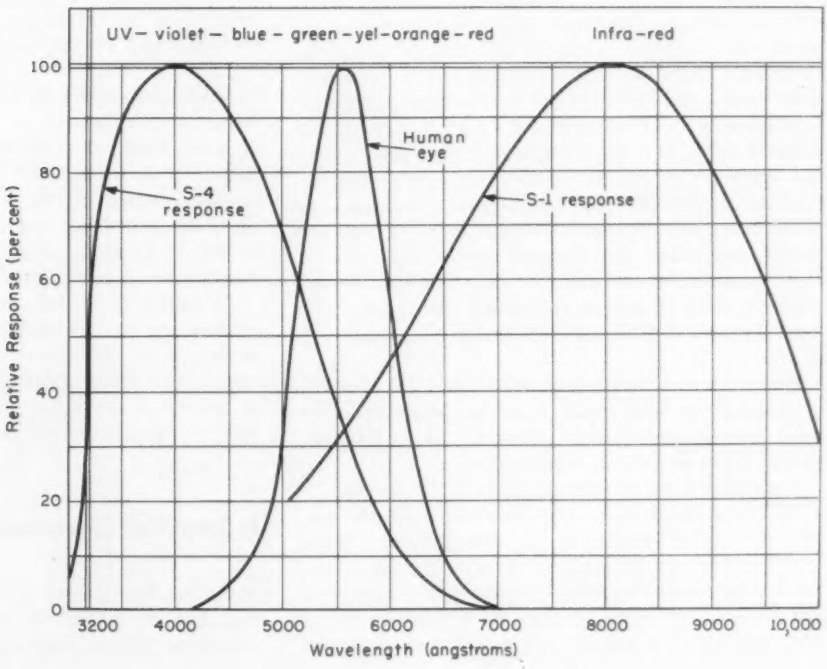


Fig. 5 — Spectral response of two phototubes, one of which is infrared-sensitive (S-1) and the other ultraviolet-sensitive (S-4), compared to the human-eye response

tercept and the more efficient it will be in collecting light. Thus, a figure of merit for a lens is the ratio of its focal length to its diameter, or its "*f* number."

A second lens, placed in the parallel light beam just ahead of the photosensitive detector concentrates the rays, as indicated in Fig. 7. If the photosensitive element is small relative to the size of the light beam, this concentration will result in a higher output signal, since rays *A'* and *B'*, which would otherwise continue in a straight line and be lost, are redirected to the photosensitive element.

Fig. 7 shows the ideal case where the light emanates from a point source. Practical lamps, even though they may have small filaments, depart from the ideal, and this departure must be considered.

At the photosensitive detector the lens is used to collect more light than would be intercepted by the detector element itself, Fig. 7. Thus, at the receiving end, improved sensitivity results from the use of larger diameter lenses up to the point where the size of the lens becomes equal to the size of the filament image.

Apertures are used at the receiving end to reduce or eliminate the effect of stray light from sources other than the main light source. Fig. 8 shows how the image of the light source is focused to pass through an aperture in a mask located between the lens and the detector. Stray light is focused onto the mask and cannot affect the detector. The size of the aperture should be small enough to eliminate all sources of stray light, but not so small that it blocks any of the light from the light source.

Mirrors can be used to direct the light beam where a single straight-line path is not sufficient. Small mirrors, if they do not intercept a sufficient cross-sectional area of the beam, will result in decreased sensitivity. Approximately 80 per cent of the light reaching a clean rear-surface mirror will be reflected. This means that two 80 per cent reflection mirrors used together will transmit only 64 per cent of the original light. It is readily apparent that only a very few mirrors can be employed without a drastic reduction in sensitivity. Front-surface mirrors are much more efficient but are more delicate and are usually not suited to industrial applications.

A reduction of at least 10 per cent can be expected at each transmission through plate glass. The exact amount will depend upon the glass used.

Filters have already been mentioned as a means of making the light beam invisible. Many reflected light systems also employ filters to aid in differentiating between two or more colors.

Photosensitive detectors are basically "color-blind." That is, although they may produce different outputs for equal excitation at two different wave lengths, they can be made to produce the same output for each color by adjusting the light intensity of the two colors. Thus, it may be desired to detect the presence of a red line on a yellow background using reflected light, but this may not be possible if both the red and yellow light received by the detector result in equal output signals.

Filters should be selected which will pass the desired color much more readily than the others. In the case just mentioned a red filter which would pass red but not pass yellow, or vice versa, would enable the detector to readily differentiate between the two colors. Of course, since the photosensitive devices themselves have a spectral response characteristic which is predominantly sensitive to a certain range of colors, it is often possible to differentiate between two colors without the use of filters.

Reflected light scanning is not as commonly applied as direct or transmitted light scanning. But this is because of the general lack of familiarity with such systems. In Fig. 9 are the two common arrangements of light source and photosensitive detector for reflected-light scanning as well as an arrangement for transmitted-light scanning of moving webs.

The signals produced by diffuse reflection are generally quite small compared to those obtained using transmitted or direct-light scanning with the same components. The reason is that light is reflected in all directions from the matte surface and only a small percentage reaches the detector. Therefore, it is desirable to locate the detector as close as possible to the surface from which reflection takes place to obtain maximum sensitivity.

Specular reflection occurring from surfaces such as tin foil can produce signals almost as strong as direct-light scanning. Small dents or wrinkles may have a major effect on the amount of light received and this type of scanning should be avoided if a diffuse-reflection system can be used. Increasing the size of the light spot to make it large relative to the size of the imperfections, and moving the detector as close as possible to the material to minimize the effect of the varying angles of the reflected rays, will improve system reliability.

Modulated light can be used in combination with lenses and apertures to further reduce the effect of stray light. A motor-driven disc chops the light before it is transmitted. The receiver contains an amplifier tuned to this modulating frequency. Stray light of any other frequency will have no effect unless so much is received that the photosensitive detector becomes saturated.

In addition to being extremely sensitive, these devices are almost perfectly fail-safe since any interruption of the signal can be used to de-energize the output relay. This relay will drop out in case of failure of the lamp, motor, power supply, or almost any portion of the amplifier.

▶ Amplifier Characteristics

Among the factors to be considered in choosing a circuit are sensitivity, speed of operation, time intervals or delays required, power-handling capabil-

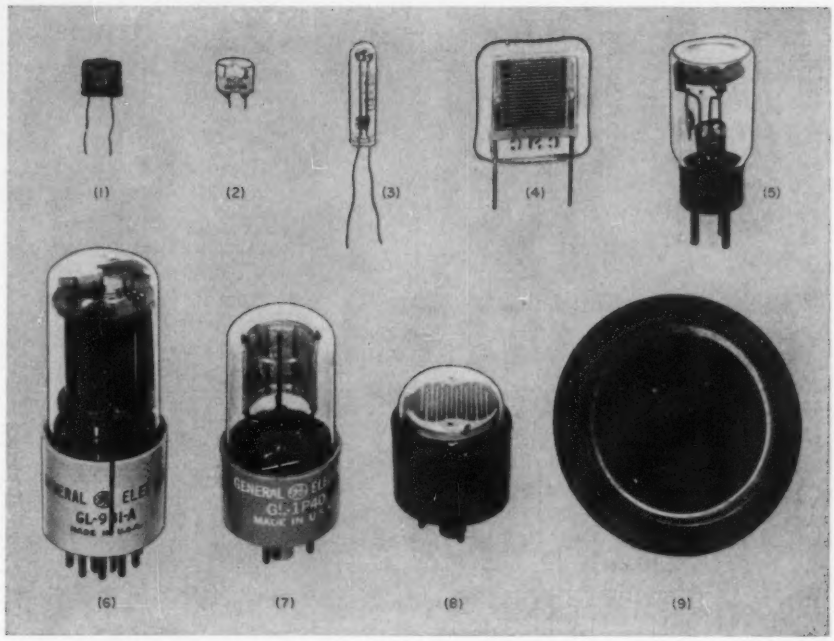


Fig. 6 — Several photosensitive detectors showing range of sizes and shapes available. Detector types include: 1. Germanium phototransistor. 2. Cadmium-sulfide, single-crystal cell. 3. Cadmium-selenide cell. 4. Cadmium-sulfide, broad-area cell. 5. Red-sensitive, gas-type photoemmissive tube. 6. Blue-sensitive, vacuum-type photomultiplier tube. 7. Red-sensitive, gas-type photoemmissive tube. 8. Cadmium-sulfide, broad-area cell. 9. Photovoltaic selenium cell

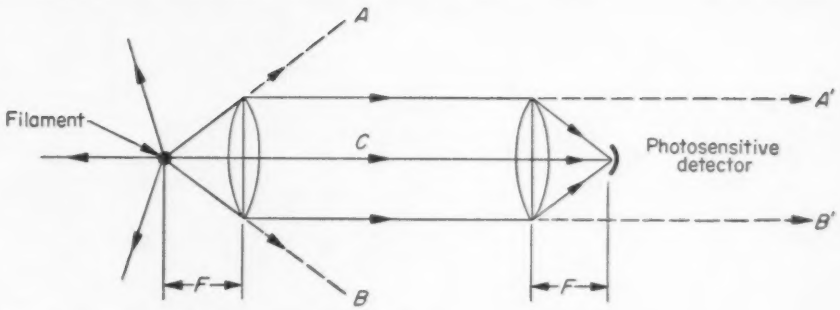


Fig. 7—Simple lens system for directing light from lamp filament to photosensitive detector

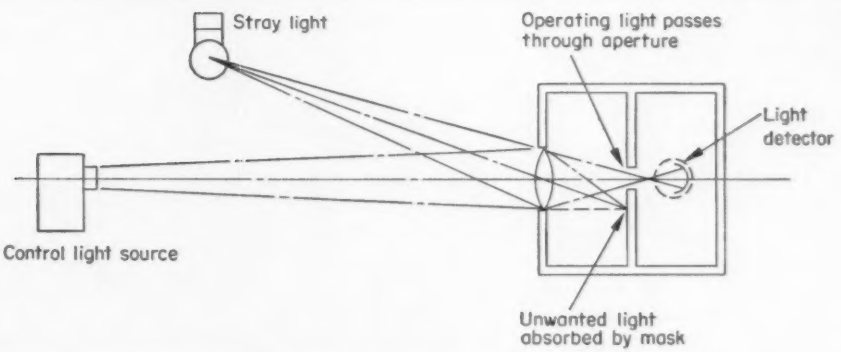


Fig. 8—Lens and mask combined with an aperture to eliminate stray light on photosensitive detector

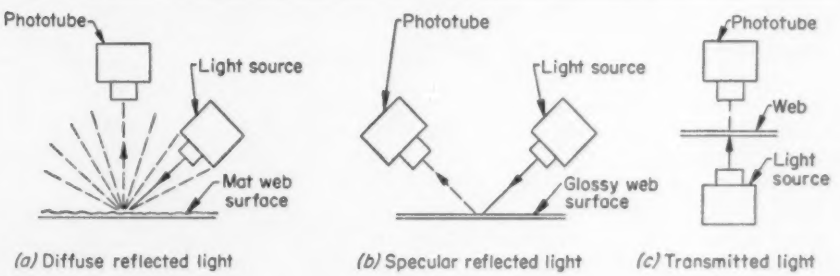


Fig. 9—Common arrangements of light source and photosensitive detector for reflected and transmitted-light systems for scanning moving webs

ity, degree of fail-safe operation, and physical size. Most manufacturers offer separate light sources and photosensitive detectors which can be used with any of a variety of amplifiers to meet the desired system characteristics.

Sensitivity of a system is limited by the signal-to-background ratio of the whole system. The majority of photoelectric relays are required to open or close a contact when the light beam is broken and remain in this state until the beam is re-established. Direct-coupled amplifiers are often employed to obtain this performance. Stray light, dark current or leakage within the photosensitive element, and amplifier drift combine to mask the desired signal and provide a ceiling to the possible sensitivity.

Stray light is a function of the optical system. Photoconductive cells and transistor amplifiers are more subject to dark current and drift at the present stage of the art than are vacuum or gas phototubes and vacuum-tube amplifiers. Ordinarily, therefore, the more stable vacuum-tube system is capable of greater sensitivity than the equivalent semiconductor device where dc coupling is required.

Capacity-coupled amplifers are available and will cause operation of the output relay in response to a sudden change in light level. In applications where they may be applied, greater sensitivity is possible than with direct-coupled amplifiers since dark current, amplifier drift, and steady stray light will have a negligible effect.

Speed of operation is an important factor in many applications. In some cases, such as counting, the maximum number of operations per minute may be of importance. At other times, operation from extremely short-duration light changes may be desirable.

Circuits using dc power supplies for both detector and amplifier are inherently capable of short operating times. Alternating-current systems are less expensive but impose a definite lower limit on the minimum duration of a light change required to operate the relay—greater than one-half cycle of the supply frequency. Ac systems are capable of operating rates of several hundred per minute.

In dc systems, time delays may be introduced by the photosensitive element, cable capacity between detector and amplifier, or the amplifier and relay combination. Photoemissive detectors are extremely fast, and even where gas phototubes are used they introduce a negligible delay. Photoconductive cells are available with a wide variety of time constants. The delay introduced by some of these cells may be the limiting item in system response. Others have negligible delay.

Time delays and time intervals of various types are available. A time delay can be used to prevent operation of the relay until the light change has been maintained for a period of time. This technique might be applied where a relay is set up to detect a backup on a conveyor. As long as the light beam is broken and then restored by passing objects the relay remains unoperated. When a backup occurs, the light beam is broken and not restored, and after a brief delay the relay operates.

Another type of delay or timed interval is available to maintain the relay in its operated position for a set period of time after a light change. This is often needed to provide sufficient time for operation of auxiliary equipment controlled by the relay, when the duration of the light change is very short.

Fail-safe operation of a system involves all aspects of an application as well as the photoelectric relay itself. Certain generalizations can be made, but it is necessary to examine alternative systems in considerable detail to determine the one which offers the greatest degree of fail-safe operation.

Power-handling capability depends upon the output relay. Most photoelectric relays have contact ratings of 5 to 10 amp. Different manufacturers

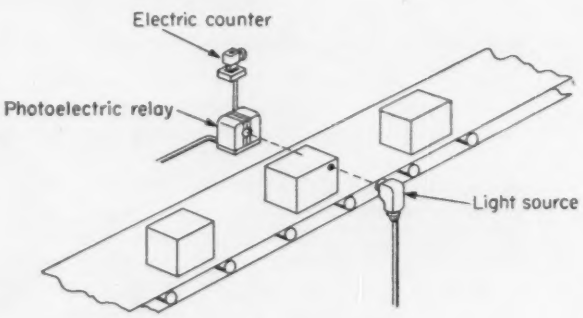


Fig. 10—Typical set-up for counting objects on a conveyor with a photoelectric relay

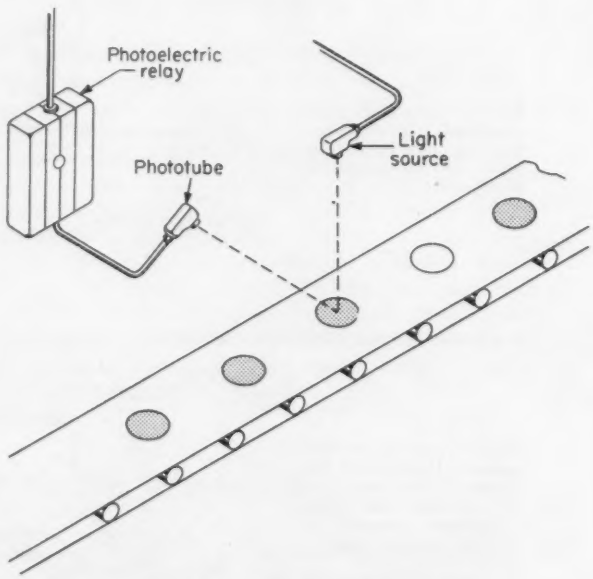


Fig. 11—Photoelectric relay system for inspecting lacquer coatings on tin-can tops

use different standards of relay life in determining ratings so it is difficult to compare on the basis of nameplate rating alone. The majority of photoelectric relays are provided with sensitive output relays with contacts suitable for use in control circuits. When applied in this way, they may have a life of several million operations. If used at published ratings, the contact life will often be reduced to a few hundred thousand operations. Some models, such as shown in Fig. 1, contain relays capable of controlling up to 1 hp, or may be connected to operate small solenoids directly from the plate circuit of the power-output tube.

Design Applications

Counting was one of the earliest applications of photoelectric relay systems. A typical system, Fig. 10, counts the total number of objects passing by on a conveyor. Often it is desirable to count separately the number of several types of different articles on the same conveyor. This can usually be done by making use of differences in the physical characteristics of the different articles, such as height, length, or color. If physical characteristics are too nearly identical, code marks can often be applied; for example, reflective-tape strips placed at different heights on different products in identical cardboard boxes. Generally a separate photoelectric system will be required for each type of article being counted on a common conveyor.

Inspection is another broad field where photoelectric relays can relieve human operators of tiring, routine tasks. This is particularly true where a single quality of a product is being inspected, the rate of production is high, and the inspection is of the "go, no-go" variety. Such applications often

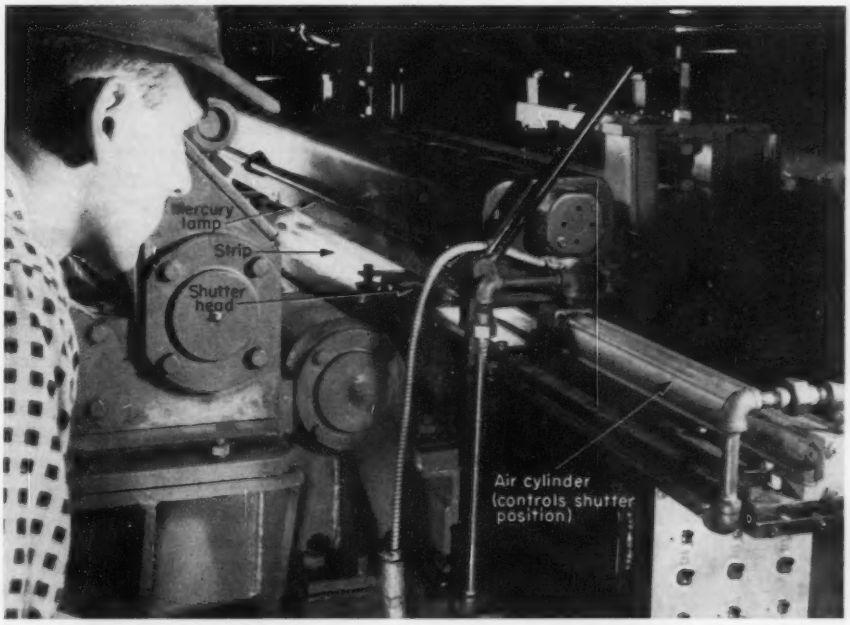
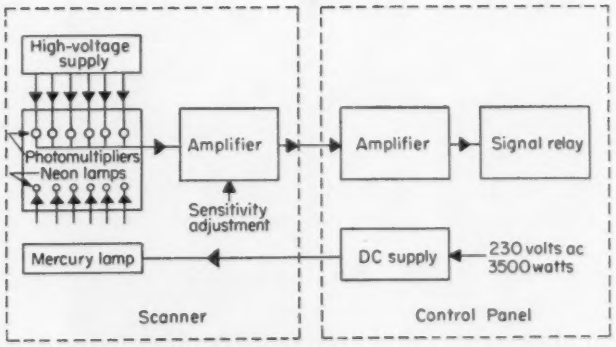
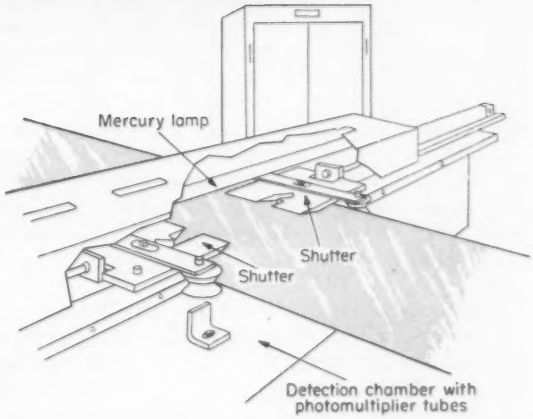


Fig. 12—Pinhole detector for inspecting tin plate to within $\frac{1}{8}$ in. of edge. Light source which illuminates tin plate is a UA9 mercury lamp rated at 3000 watts and 120,000 lumens. Six 931A photomultipliers, feeding a capacitor-coupled amplifier, detect pinholes as small as 0.001 in. in diameter moving at 4000 fpm. The shutters are used to prevent stray light from passing around the edges of strip to the detection chamber. The neon lamps serve to check operation of photomultipliers





involve sensing the presence or absence of coatings, gaskets, labels, holes, etc.

Fig. 11 illustrates one system in which a difference in reflection is used to detect the absence of a lacquer coating on a can top. The yellow lacquer greatly reduces the amount of reflected blue light compared to that reflected from an unlacquered top. A blue-sensitive phototube, possibly in combination with a blue filter, will readily sense this

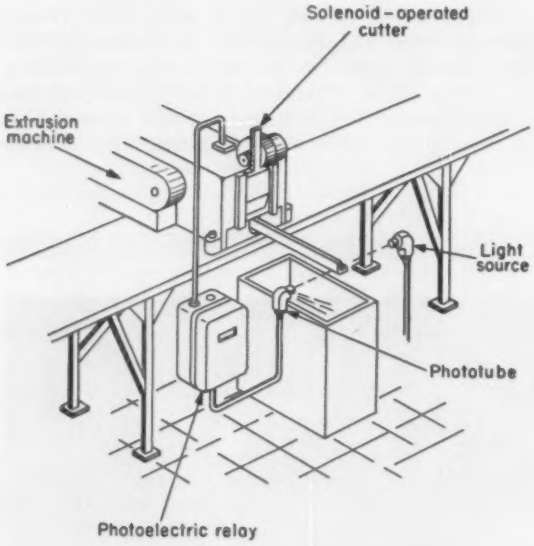


Fig. 13—Photoelectric control for cutting off extruded materials. Length of cut is determined by distance of light source and phototube from machine. Tolerances in cut length of 1/16 in. are readily obtainable

difference and operate the photoelectric relay to cause an alarm or rejection of the faulty part.

Quite often inspection systems require a switch, an additional photoelectric relay, or other means to prevent inspection from occurring except when the object is in proper position to be inspected.

Special-purpose equipment, such as the pinhole detector in Fig. 12, sometimes requires special photoelectric relay system designs.

Simple photoelectric relays are not well suited to inspection which requires judgment. For example, it is easy to determine the presence or absence of a coat of white paint, but much more difficult to pass paint with greater than 80 per cent reflectivity and reject that with less than 80 per cent reflectivity. Another unfavorable situation could exist where it is permissible to pass a single, fairly large defect (spot), but a number of small defects must result in rejection. Special-purpose equipment can be built to handle such situations.

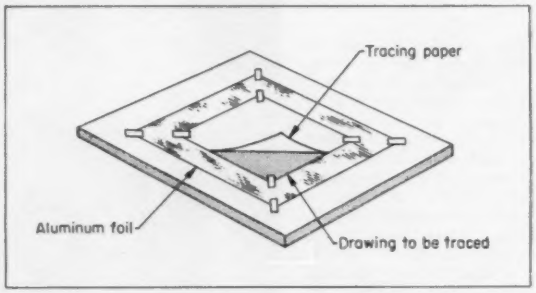
Alarm systems may be set up to monitor constantly some machine function and sound an alarm or initiate action when a change occurs. A familiar example of this type of system is the web-break detector. A break in the web sends a beam of light to the phototube and sounds an alarm. Since such systems may be called upon to operate very infrequently, it is especially desirable that they be made as fail-safe as possible.

Control of many diverse functions may be accomplished by using the same basic components. The same photoelectric relay which opens a door automatically can be used to control the length of extruded shapes. In Fig. 13 is a system which operates a cutter when the extruded material breaks the light beam.

Tips and Techniques

Reflector

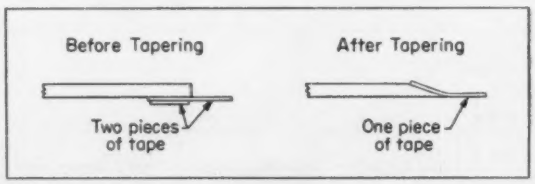
When a drawing is made on translucent paper, tracing can be simplified by performing the work on a base of aluminum foil attached to the drawing board. Light lines on the drawing, which are



poorly visible through tracing paper, become distinct after the addition of upward light reflected from the foil.—GORDON C. VORE, *project engineer, Micro Switch Div., Minneapolis Honeywell Regulator Co., Freeport, Illinois.*

Holding Le Roy Guide

When the square ends of a Le Roy lettering guide are tapered, only one piece of tape is needed to hold



the straightedge steady while lettering. This makes tape application quicker and easier.—J. R. CHENEY, *St. Louis, Mo.*

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WHY INVESTMENT CASTINGS?

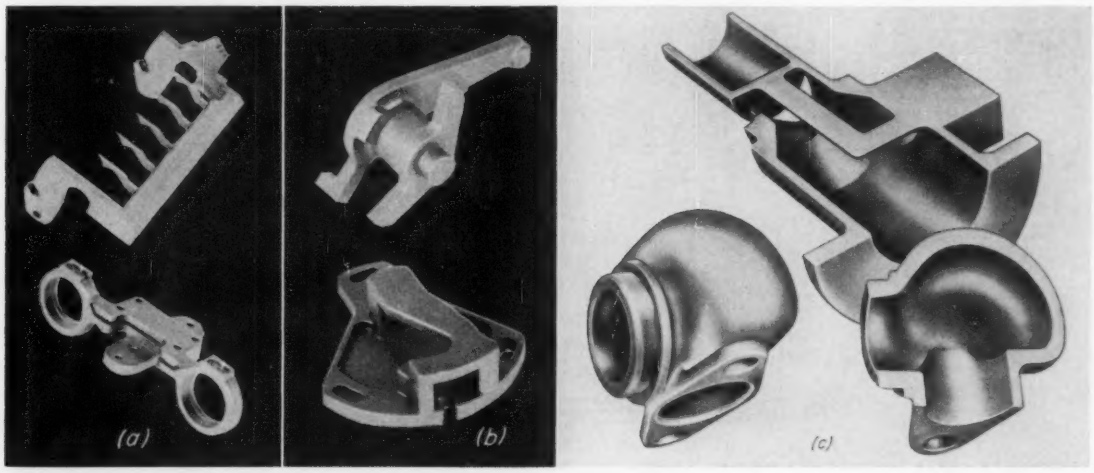
By WILLIAM H. SHUMAN
Hitchiner Manufacturing Co. Inc.
Milford, N. H.

EVERY process has certain inherent advantages. For investment castings, these advantages largely revolve around the flexibility of the process in casting almost any conceivable shape, and in the broad alloy selection. Here, in pictures, is a short design guide on when and where to specify investment castings.

1 Design Flexibility

Inherent in the investment-casting process, flexibility can provide substantial savings in production costs by eliminating secondary operations.

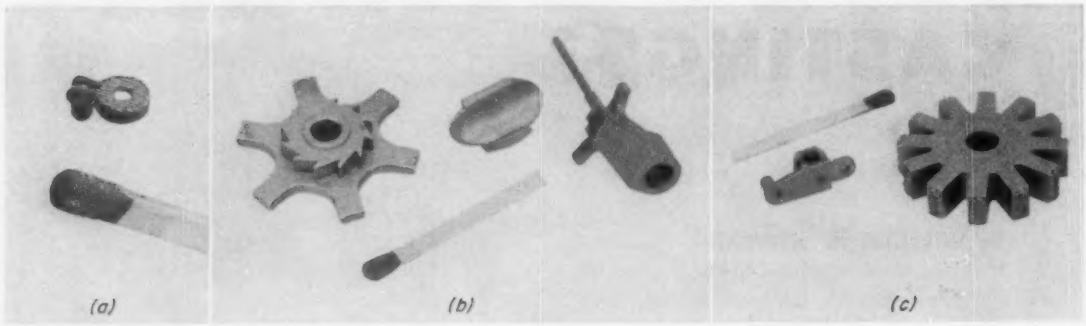
These six investment castings demonstrate the broad variety of irregular surface curvatures, thick and thin sections, shaped cores, and internal surfaces that are obtainable. The five identical thin sections extending from casting at *a*, top, are only 0.032-in. thick. Thousands of irregularly shaped components are designed only with a particular function in mind and no compromise with production limitations, *b*. Complex, awkward interior shapes, c, are possible because of the broad freedom in coring that is possible in the process.



2 Detail Reproduction

Accurate detail rendition is significant to the engineer both in the ability of the process to produce high-quality pieces in extremely small sizes and to provide precise surface detail on parts of any size.

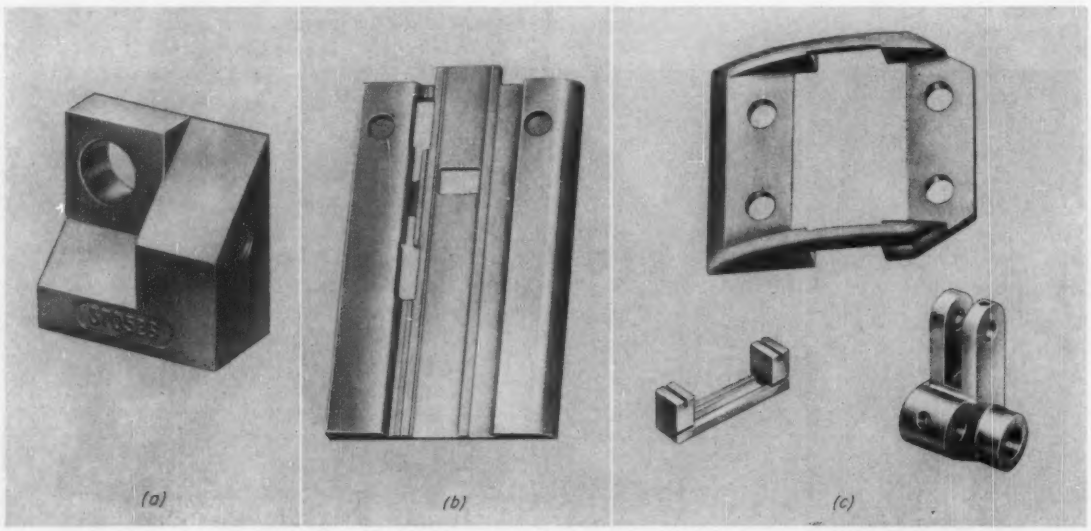
Miniature parts for peepsights, *a*, are both complex in shape (facing thin flanges and hole) and surface detail (grooves on annular surface). Precise gear-tooth surfaces, *b*, left, represent components requiring reproduction of detail. Numbers on the ends of the radial sections of a business-machine component, *c*, must stand out sharply and the component must be reproduced in large quantities.



3 Tolerances

As in design of components for any other production process, dimensional tolerances specified for investment castings should be as wide as possible to minimize cost of manufacture. These tolerances were given in detail in MACHINE DESIGN, August 22, 1957, Page 133. The particular alloy used in investment casting a component has no effect on the tolerance limits. Although ferrous and nonferrous molds differ in construction and material, the accuracy of the resulting casting is not altered.

A component with very heavy sections, *a*, may show a sink or depression in flat surfaces enclosing a heavy mass of metal; special techniques are necessary to produce a wax pattern free of sink. Warpage can occur in flat, comparatively thin sections, *b* and *c*. Special precautions prior to casting and subsequent sizing were required in these pieces to maintain dimensional accuracies specified. The distance between two long arms or extensions, *c*, may be hard to hold within tolerances.

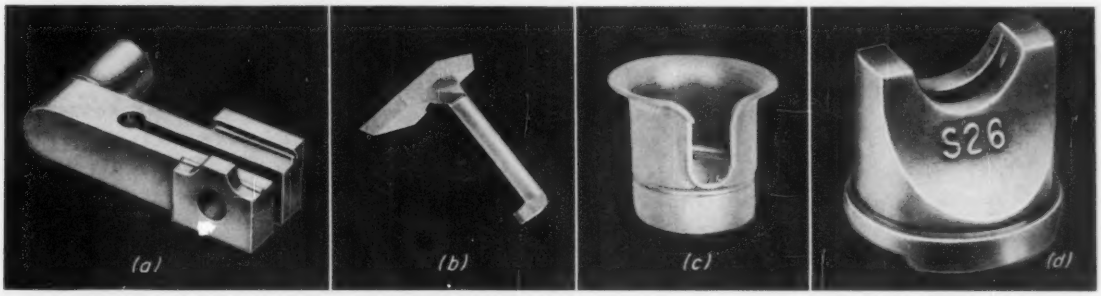


4 Alloy Selection

Although some alloys cause unusual foundry problems, and others are impossible to cast at all, these are rare and occur only as minor limitations in any alloy series. The designer can select from a large number of alloys to meet functional requirements either in the as-cast condition or with subsequent heat treating. Thus, alloy characteristics are obtained that are not commonly available in wrought form.

Cost of an investment casting is affected very little by the metal cost. Casting characteristics of the metal far outweigh its cost in arriving at the over-all cost of the casting. A relatively expensive alloy can frequently produce cost savings over the same component cast in a lower-cost alloy.

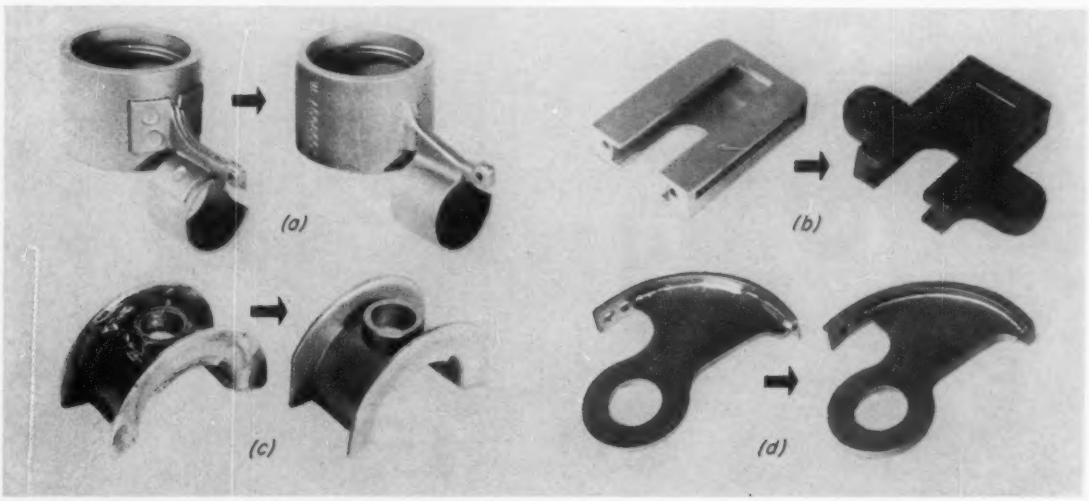
Gage mount, *a*, was originally considered in SAE 8620 stainless, but beryllium copper was selected because of its excellent castability; a 15 per cent cost saving was achieved. The gaging finger, *b*, is cast in tool steel to gain resistance to deflection. Plating was avoided by casting the ferrule, *c*, in 300-series stainless. Stellite, a nonmachinable alloy, was selected for the spray nozzle, *d*, used for paints having ground glass added for reflective properties.



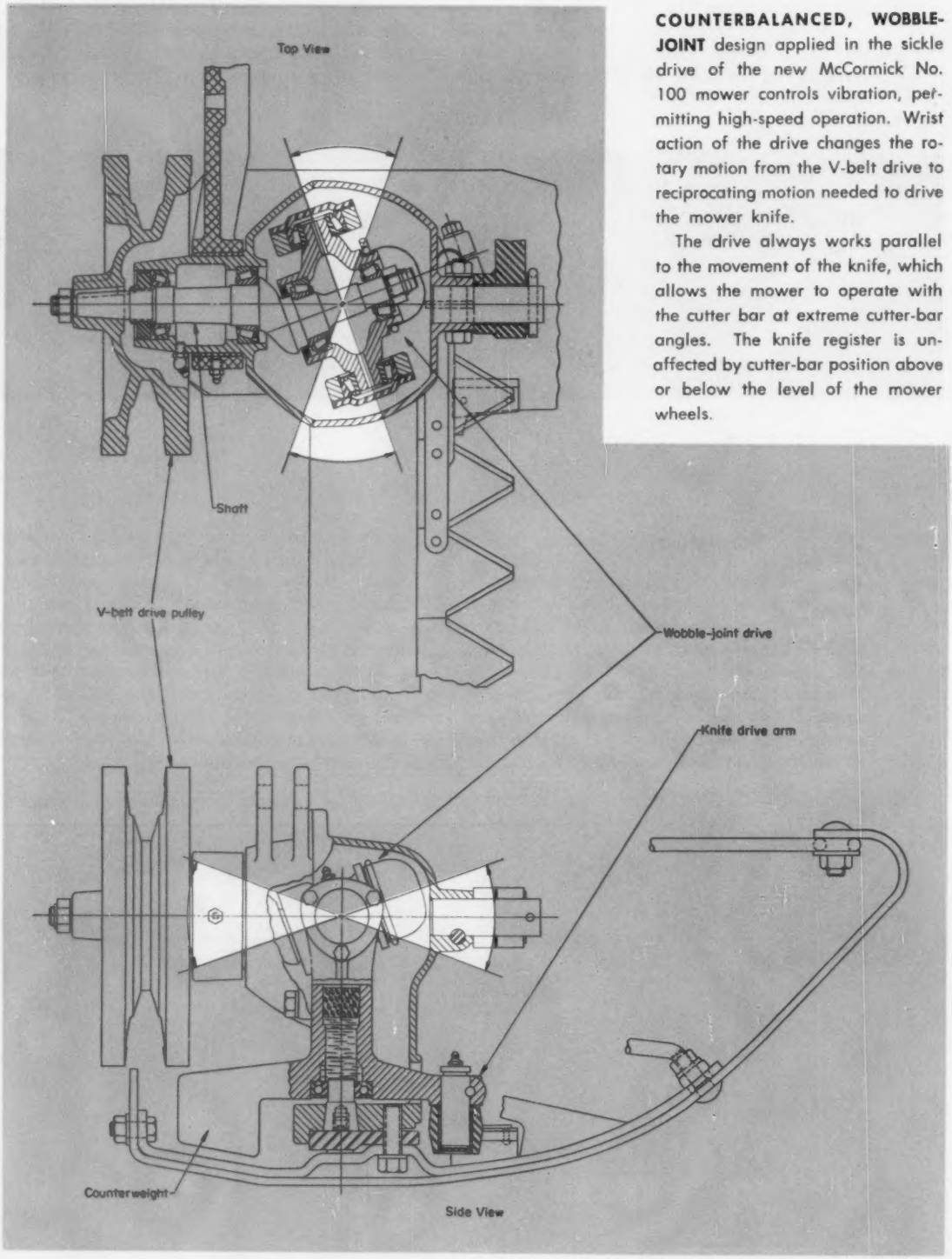
5 Design Freedom

In progressing from a component designed for function to one designed for the investment-casting process, the change in the appearance of the casting is usually negligible. Occasionally, minor design changes are made in the interests of economy (such as avoiding the necessity for an auxiliary casting gate and eliminating excess material) and performance (such as stiffer sections and greater precision).

Redesigned from a spot-welded assembly, bracket *a* is cast in silicon iron to provide magnetic characteristics. Investment casting replaced machining from solid, *b*, and permitted adding ears which were desired but too expensive to machine. Clean appearance of cast part, *c*, is an added bonus over fabrication. Welded stampings, *d*, were costly and tolerances on radius of large curve could not be held. Casting duplicates original spot-welded design in a one-piece cast "assembly."



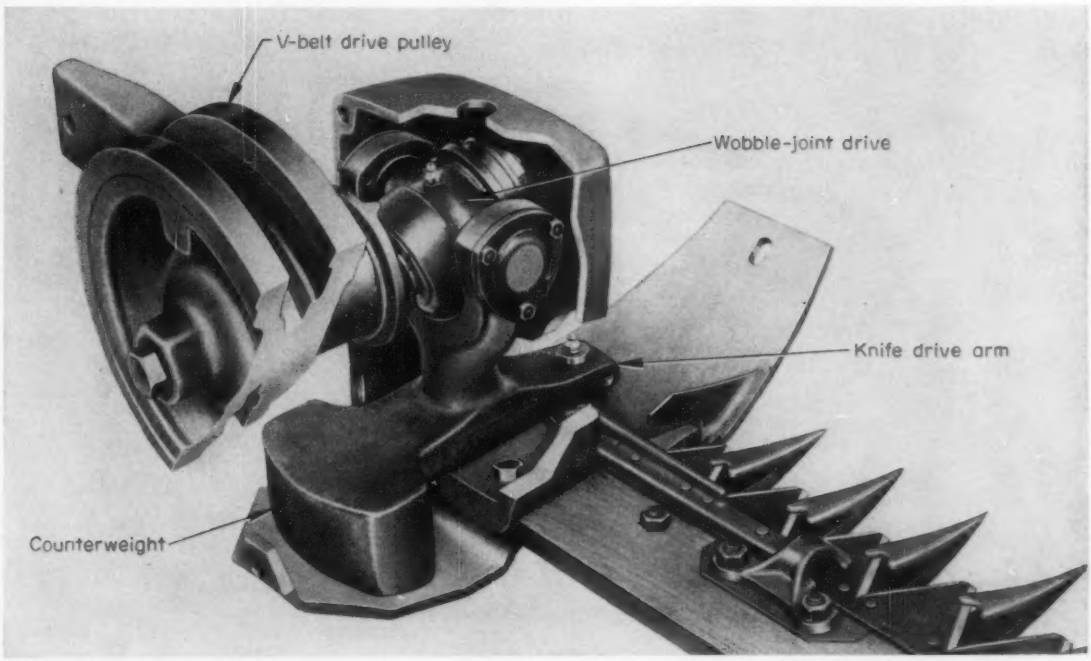
Wrist-Action Drive Converts



COUNTERBALANCED, WOBBLE-JOINT design applied in the sickle drive of the new McCormick No. 100 mower controls vibration, permitting high-speed operation. Wrist action of the drive changes the rotary motion from the V-belt drive to reciprocating motion needed to drive the mower knife.

The drive always works parallel to the movement of the knife, which allows the mower to operate with the cutter bar at extreme cutter-bar angles. The knife register is unaffected by cutter-bar position above or below the level of the mower wheels.

Rotary Motion to Reciprocating

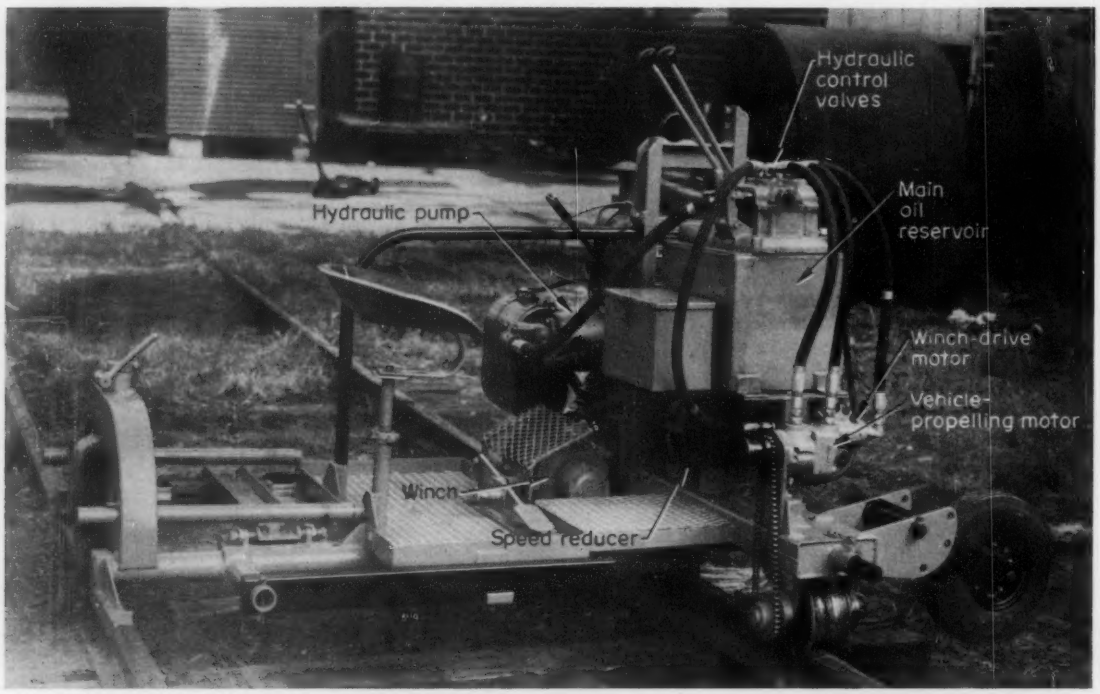


ACCURATE VIBRATION CONTROL is achieved since the knife drive arm pivots in the center and is counterbalanced with a weight in the rear. The counterweight moves in the opposite direction to the knife drive arm to counterbalance the mass of the knife.

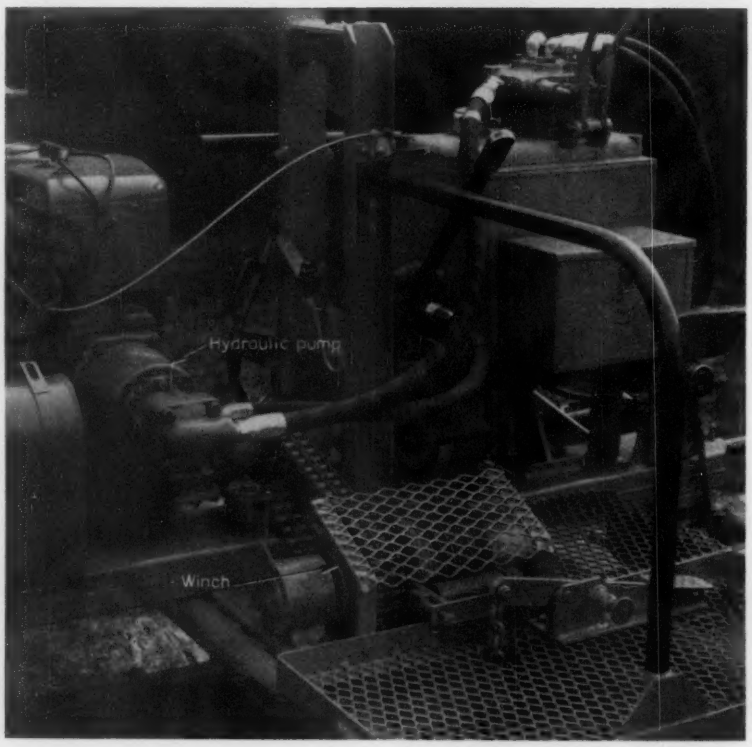
CUTTER BAR FOLDS BACK across the body of the mower for transport and storage, eliminating overhead-clearance problems and cutter-bar whipping.

An adjustable breakaway feature permits the cutter bar to swing back 42 deg if it hits an object

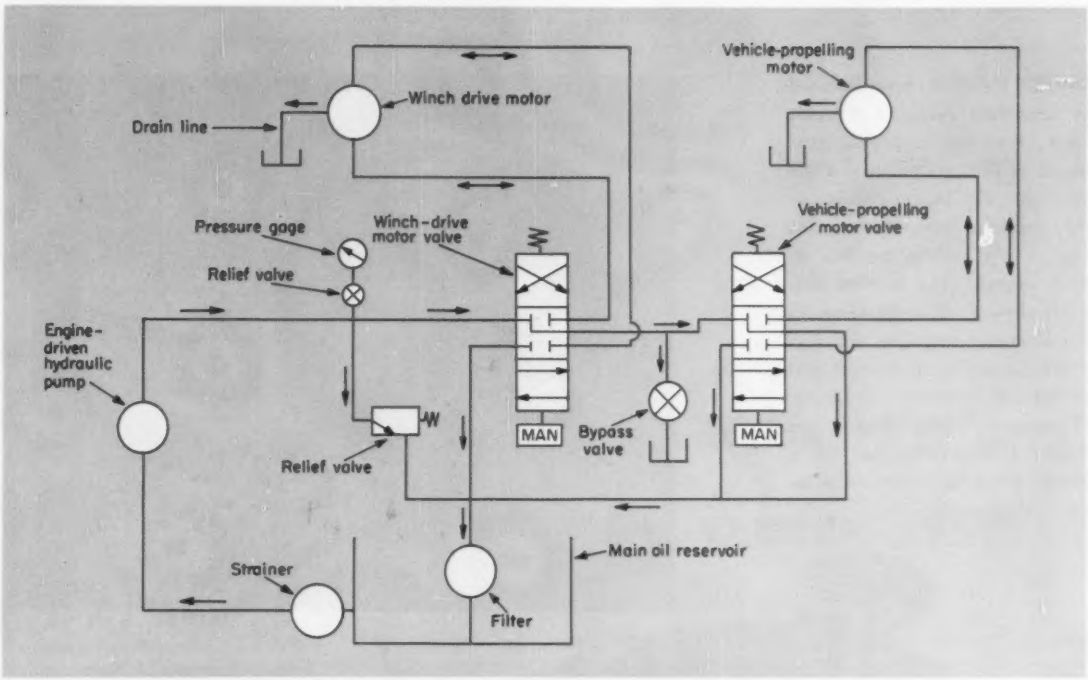
Engine-Driven Pump Propels



HYDRAULICALLY POWERED tie-handling machine cuts time and cost of replacing and repositioning railroad ties. Designed and developed by Fairmount Railway Motors Inc., Fairmount, Minn., the new unit permits two men to remove ties at the rate of four a minute, on raised track. Also, with this machine, two men can insert two ties a minute under the tracks.



Vehicle and Operates Winch



TWO SEPARATE CIRCUITS, which are used in the tie handler's hydraulic system, control oil flow to two vane-type motors. One fluid motor propels the tie handler through a roller-chain drive. The second motor drives a winch through a speed reducer and a roller-chain drive.

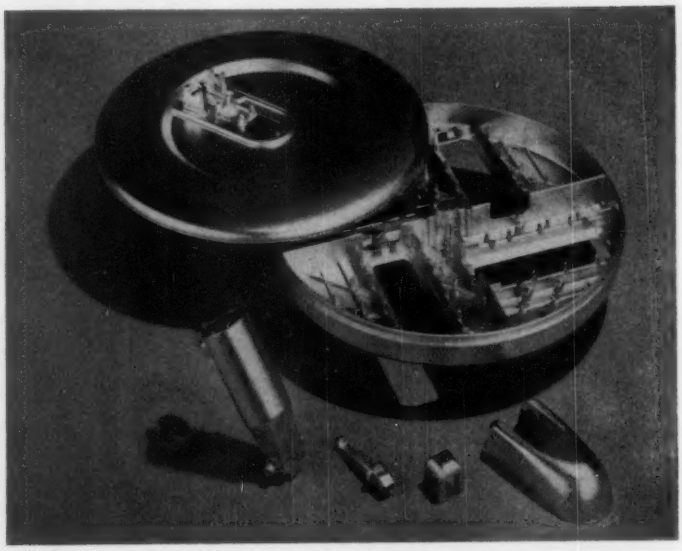
A balanced vane pump can furnish 7.25 gpm of oil at 1800 rpm from an 8.5-gal oil reservoir. The pump is directly driven by a two-cylinder, four-cycle gasoline engine. The pump and the two hydraulic motors are made by Denison Engineering Div., American Brake Shoe Co., Columbus, Ohio. The pump is rated at 2000 psi, although both hydraulic circuits are set to operate no higher than 1750 psi.

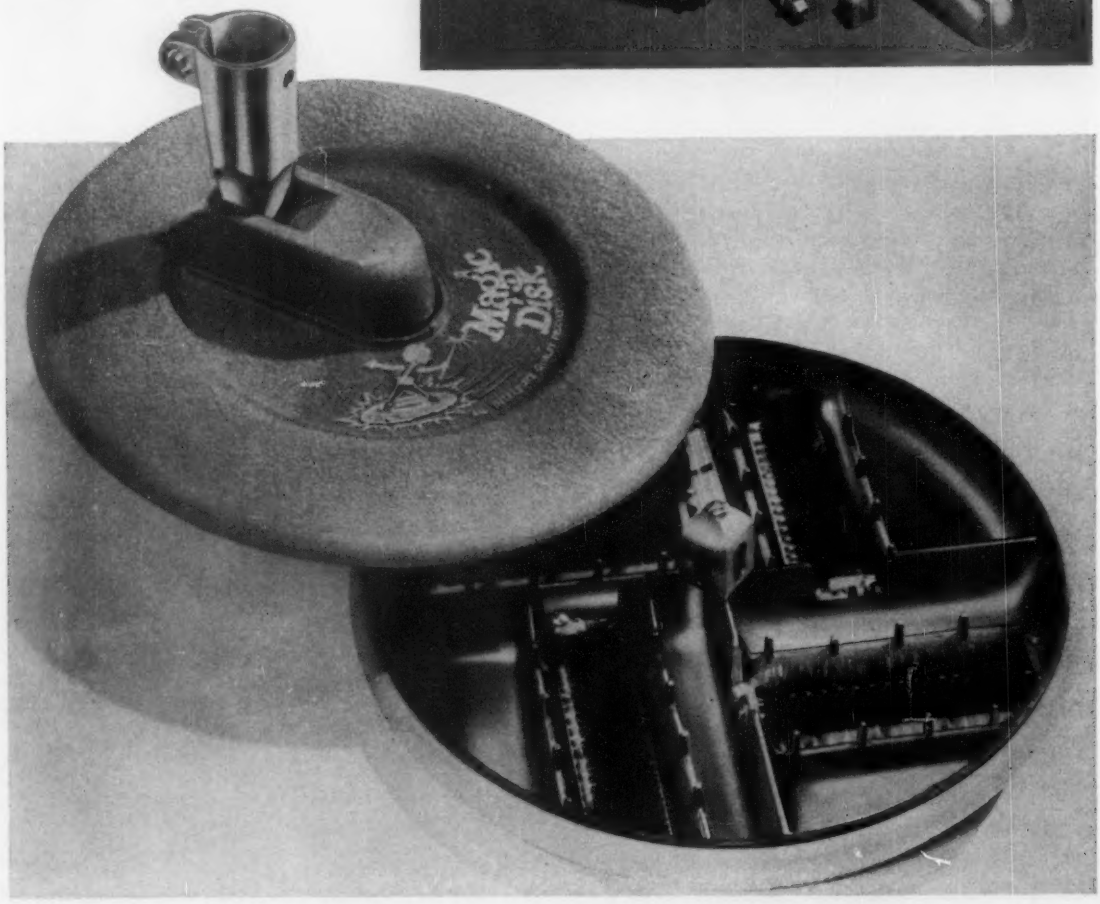
MAXIMUM PULL of 3900 lb can be applied on the cable. In operation, the cable is attached to the tie by a special clamp. The technique for inserting a tie is shown. An adjustable-length steel boom is added to extend the cable for removing a tie.

Hinged arms can be swung out into position, and ties placed on them as counterbalances, if required.

Right-Angle Mounted Brushes Clean In Any Direction of Travel

CARPET SWEEPER manufactured by Interstate Precision Products Corp., Anaheim, Calif., is composed of only six aluminum die castings. The Magic Disc, a design imported from Sweden, uses four freely rolling brushes at right angles. The brushes protrude through four openings in the base and rotate as the disc-shaped machine is pushed and pulled in various directions. Cleaning is accomplished in any direction of travel, and dirt is lifted into the four separate housing compartments.





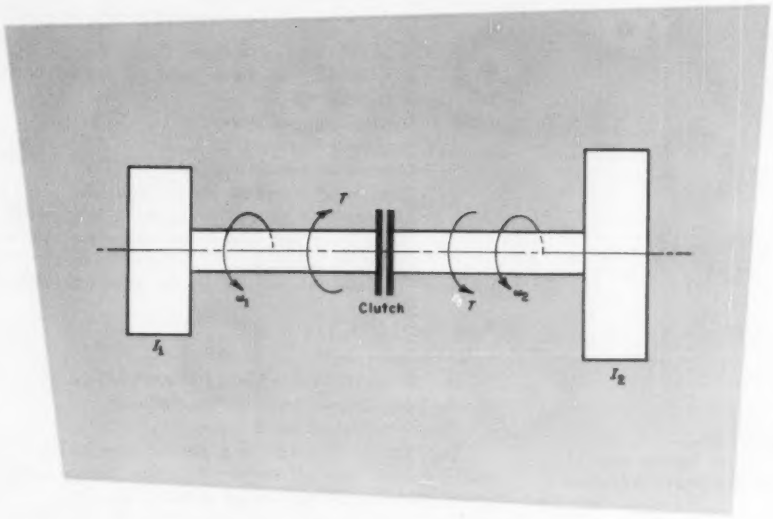


Fig. 8—Essential components of a two-inertia system joined by a friction clutch

Friction-Clutch Transmissions

Part 2

HOW TO ANALYZE A CLUTCH SYSTEM

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CERTAIN conclusions about actual friction-clutch transmissions can be drawn from simplified mathematical models. These analyses can lead to optimum design values—or suggest corrective measures for systems already designed.

In this article, two such models are studied to show methods of analysis. Reported results are confirmed by oscillographic records of an automotive example.

A separate analysis treats shunted clutches in planetary assemblies, common in the automotive field. When system performance is to be improved by adding inertia, this article tells where and how much.

Two-Inertia System

An idealized model of two rotating flywheels coupled by a friction clutch, Fig. 8, illustrates certain fundamentals in the interchange of energy in a two-inertia system. Assumptions in this analysis are:

1. Coefficient of friction is a constant, independent of rubbing speed.
2. Compliance of the system is zero.
3. No external torques act on the system.

Initially, the two flywheels rotate at different angular velocities, Ω_1 and Ω_2. Let the clutch be instantaneously applied at time $t = 0$, and let the torque exerted by the clutch on the two flywheels be a constant, T_c. This torque acts on the system only as long as there is a difference in speeds between the two shafts. Hence, equations for speeds and rate of heat dissipation hold good only for values of time $0 \geq t \geq t_o$, where t_o is the time required to couple the two shafts.

The equations of motion for the two sides of the clutch can be written:

$$I_1 \frac{d\omega_1}{dt} = -T \tag{26}$$

$$I_2 \frac{d\omega_2}{dt} = T \tag{27}$$

Integrated, Equation 26 becomes

$$\omega_1(t) = -\frac{T}{I_1} t + \Omega_1 \tag{28}$$

By analogy,

$$\omega_2(t) = \frac{T}{I_2} t + \Omega_1 \tag{29}$$

The relative velocity of I_1 with respect to I_2 is

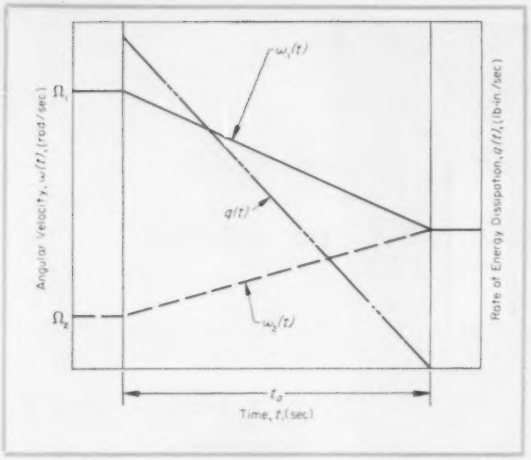


Fig. 9—Change of angular velocities of two inertias coupled during a time period t_o and variation of energy dissipation in the same period

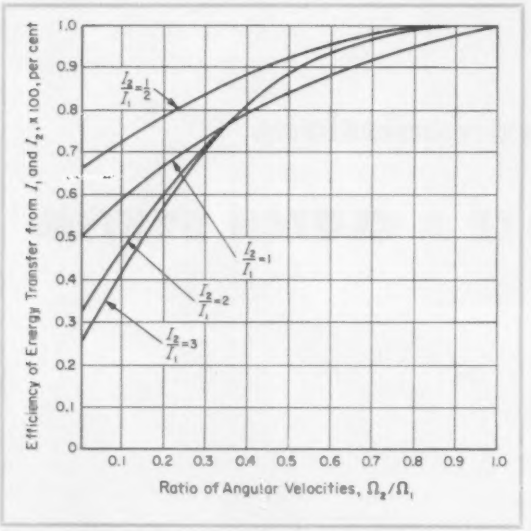


Fig. 9a—Efficiency of energy transfer from one inertia member to another, for selected ratios of the two inertias vs. ratio of angular velocities of the same inertias at start of engagement (plots of Equation 35)

Nomenclature

A = Total friction face area, sq in.
E_e = Kinetic energy of engine expended during clutch engagement, lb-in.
E_0 = Kinetic energy of system at $t = 0$, lb-in.
g = Basic gear ratio
I = Moment of inertia, lb-in.-sec^2
I_E = Moment of inertia of engine, lb-in.-sec^2
I_d = Moment of inertia of all parts, including additional shock-absorbing mass, on output side of clutch, lb-in.-sec^2
I_V = Equivalent moment of inertia of vehicle, lb-in.-sec^2
K_1 = Ratio I_2/I_1
K_2 = Ratio Ω_2/Ω_1
m = Slope of friction-velocity characteristic curve
n = Number of clutch friction surfaces
P = Total axial load, lb
Q = Energy dissipated in a specific time period, Btu
$q_o(t)$ = Unit rate of energy dissipation during clutch closing, Btu per sec per sq in.
$q(t)$ = Unit rate of energy dissipation, Btu per sec per sq in.
R_o, R_i = Clutch face radius, outside, inside, in.
S_1, S_2 = Sun gears
T = Torque, lb-in.
T_c = Torque, constant, lb-in.
T_E = Engine output torque, lb-in.
T_o = Output load torque, lb-in.
T_R = Constant dissipative load torque; Road load torque, lb-in.
t = Time, sec
t_o = Time period to close a clutch, sec
V = Slip velocity, ips
v = Linear, tangential velocity, ips
β = Slope of torque-velocity curve, lb-in. per rad per sec
$\delta = (I_1 + I_2)\beta/I_1 I_2$
η = Efficiency of energy transfer, per cent
μ = Coefficient of friction
μ_0 = Kinetic coefficient of friction
ω = Angular velocity, rad per sec
ω_d = Angular velocity, sun gear on output side of clutch; Clutch drum speed, rad per sec
ω_E = Angular velocity, engine output, rad per sec
Ω_o, ω_o = System output angular velocity, rad per sec
ω_r = Relative angular velocity, rad per sec

$$\omega_r(t) = \omega_1(t) - \omega_2(t)$$
$$= -T\left(\frac{I_1 + I_2}{I_1 I_2}\right)t + \Omega_1 - \Omega_2 \qquad (30)$$

The rate at which energy is dissipated in the clutch during the engagement period is

$$q(t) = T\omega_r(t) = T\left[\Omega_1 - \Omega_2 - T\left(\frac{I_1 + I_2}{I_1 I_2}\right)t\right] \qquad (31)$$

To determine the engagement period, t_o, consider that when $t = t_o$, $\omega_1(t) = \omega_2(t)$. Then

$$t_o = \frac{I_1 I_2(\Omega_1 - \Omega_2)}{T(I_1 + I_2)} \qquad (32)$$

Total energy dissipated during the operation is obtained by integrating Equation 31 between the limits $t = 0$ and $t = t_o$. The result is

$$Q = \int_0^{t_o} q(t)\,dt = \frac{I_1 I_2(\Omega_1 - \Omega_2)^2}{2(I_1 + I_2)} \qquad (33)$$

Efficiency with which energy is transferred from I_1 to I_2 during the clutching operation is

$$\eta = 1 - \frac{Q}{E_0}$$
$$= 1 - \frac{I_1 I_2(\Omega_1 - \Omega_2)^2}{(I_1 + I_2)(I_1\Omega_1^2 + I_2\Omega_2^2)} \qquad (34)$$

Upon substitution of symbols for ratios, $K_1 = I_2/I_1$ and $K_2 = \Omega_2/\Omega_1$, Equation 34 becomes

$$\eta = 1 - \frac{K_1(1 - K_2)^2}{(1 + K_1)(1 + K_1 K_2^2)} \qquad (35)$$

These results are shown in Fig. 9 and 9a. From the figures and the equations, summarized observa-

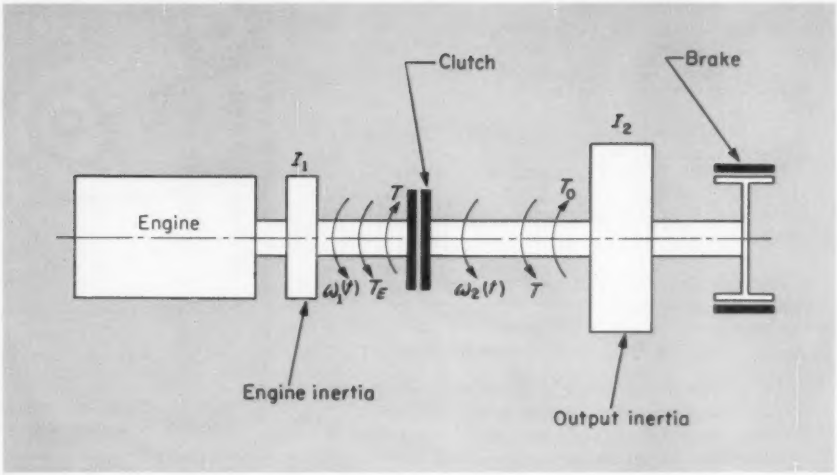


Fig. 10—Elements of a complete power-transmission system consisting essentially of an engine and brake added to a two-inertia system

tions are:

1. Time required to couple the two inertias is proportional to the difference of the two initial velocities, $\Omega_1 - \Omega_2$, and inversely proportional to the clutch frictional torque.
2. Maximum rate of energy dissipation occurs at $t = 0$ and is proportional to the product of clutch torque and the difference in velocities.
3. Total amount of energy dissipated in the clutch during the slip period is a function of the inertia of the two rotors, and of the square of the difference in speeds. Energy dissipated does not depend on clutch torque or the duration of slip.
4. Efficiency with which energy is transferred from I_1 to I_2 is a function of both the ratios Ω_2/Ω_1 and I_2/I_1. This is important when designing systems that use clutches for energy transmission, for example, inertia starters.

Strict application of these conclusions is limited to cases where no external torques are acting on the system during the transition period.

System with Engine and Brake

Addition of an engine and brake to the two-inertia model creates an advanced arrangement which has all essential elements of a power transmission system using a friction clutch, Fig. 10. In the analysis of this refined version, as for the two-inertia model, compliance of the shafts is neglected.

All of the prime-mover inertia is shown accumulated in the flywheel I_1, T_E is the engine output torque, T_R is the constant dissipative load torque supplied by the drum brake, and I_2 is the inertia of the load side of the clutch. The ratio of coefficient of friction to relative sliding velocity is assumed constant.

Velocity Expressions: First, it is observed that

$$T = T_0 - \beta\omega_r = T_0 - \beta(\omega_1 - \omega_2)$$

Then, the sum of all torques acting on the engine side of the clutch is

$$I_1 \frac{d\omega_1}{dt} - \beta\omega_1 + \beta\omega_2 = T_E - T_o \tag{36}$$

Similarly, the equation for the load side of the clutch is

$$I_2 \frac{d\omega_2}{dt} - \beta\omega_2 + \beta\omega_1 = T_o - T_R \tag{37}$$

Operational calculus is used to solve Equations 36 and 37 for $\omega_1(t)$ and $\omega_2(t)$. The results are

$$\omega_1(t) = \frac{(A_1\delta^2 + B_1\delta + C_1)e^{\delta t}}{I_1 I_2 \delta^2} - \frac{\delta(C_1 t + B_1) - C_1}{I_1 I_2 \delta^2} \tag{38}$$

$$\omega_2(t) = \frac{(A_2\delta^2 + B_2\delta + C_1)e^{\delta t}}{I_1 I_2 \delta^2} - \frac{\delta(C_1 t + B_2) - C_1}{I_1 I_2 \delta^2} \tag{39}$$

where

$$A_1 = I_1 I_2 \Omega_1$$

$$B_1 = I_2(T_E - T_0) - \beta(I_1\Omega_1 + I_2\Omega_2)$$

$$C_1 = \beta(T_R - T_E)$$

$$\delta = \frac{(I_1 + I_2)\beta}{I_1 I_2}$$

$$A_2 = I_1 I_2 \Omega_2$$

$$B_2 = I_1(T_o - T_R) - \beta(I_1\Omega_1 + I_2\Omega_2)$$

Conditions for Coupling: Since the coefficient of friction in this case is a variable depending on the relative speed between clutch plates, it will be of interest to determine the conditions under which engagement, or absolute, positive coupling of the two sides of the clutch can be accomplished.

To do this, Equations 38 and 39 are differentiated with respect to time. Then, for $t = 0$, the expressions

for the accelerations of the two shafts are

$$\omega_1'(0) = \frac{T_E - [T_o - \beta(\Omega_1 - \Omega_2)]}{I_1} \quad (40)$$

$$\omega_2'(0) = \frac{T_E - T_R}{I_2} - \frac{T_E - [T_o - \beta(\Omega_1 - \Omega_2)]}{I_2} \quad (41)$$

Examination of Equations 40 and 41 yields these observations:

1. The most desirable condition for fast and positive engagement occurs when

$$T_E < [T_o - \beta(\Omega_1 - \Omega_2)]$$

that is, when clutch torque *at the moment engagement begins* is greater than engine output torque.
2. When these two torques are equal, engagement is slower than when clutch torque is the larger. Engagement time depends on the value of $(T_E - T_R)$, which must be positive to make engagement possible.
3. The rate at which $\omega_2(t)$ begins to increase, immediately after the clutch is applied, is determined by the quantity

$$(T_E - T_R)/I_2$$

4. The increase of speed of the output side of the clutch decreases the relative velocity of the clutch plates, thus increasing clutch torque. Any increase in clutch torque above the value $T_o - \beta(\Omega_1 - \Omega_2)$ causes deceleration of the input shaft. Thus, the effect of the initial increase in speed of the load side of the clutch is cumulative and leads to positive engagement.
5. When engine output torque is greater than clutch torque, at the instant of application of the clutch,

$$\frac{T_E - [T_o - \beta(\Omega_1 - \Omega_2)]}{I_1} <$$

$$\frac{T_E - T_R - [T_E - T_o - \beta(\Omega_1 - \Omega_2)]}{I_2}$$

Rate of Energy Dissipation: The expression for the average rate of energy dissipation during clutch engagement is

$$q_0(t) = \frac{T\omega_r}{A} = \frac{[T_O - \beta(\omega_r)]\omega_r}{A} \quad (42)$$

where

$$\omega_r = \omega_1(t) - \omega_2(t) = \frac{(A_1 - A_2)\delta^2 + \delta(B_1 - B_2)e^{\delta t} - \delta(B_1 - B_2)}{I_1 I_2 \delta^2} \quad (43)$$

To minimize complexity, Equation 43 is not substituted in Equation 42 at this point. The manipulation of these equations is illustrated in a numerical example, which follows.

Application Precautions: Examination of either Equation 36 or 37 discloses that when $T_o/\beta = \Omega_1 - \Omega_2$, clutch torque is zero, and the two shafts could never be effectively coupled. It is also noticed that relative initial speed is also the speed at which the kinetic coefficient of friction is zero. In practice this could never occur. The theoretical case of $\mu = 0$ is a consequence of the assumption that friction decreases *linearly* with slip velocity. When this difficulty is encountered in practice, this analysis is still usable provided that pertinent equations are properly modified and properly applied.

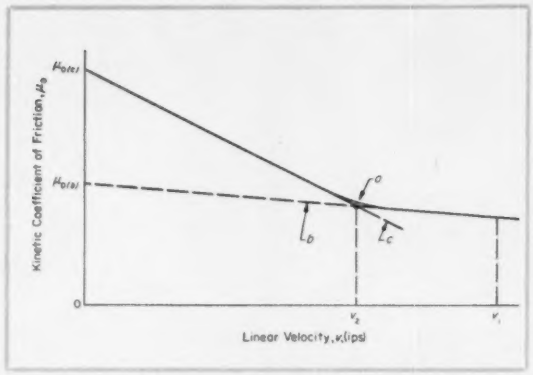


Fig. 11—Expedient relationship between kinetic coefficient of friction and linear velocity

Assume that a clutch-face material has the friction-speed characteristics shown by curve *a* in Fig. 11, and that the relative angular velocity at $t = 0$ corresponds to the average linear velocity v_1. Then, for the range of speeds v_1 to v_2, the values of m and μ_0 could be determined from straight line *b*. For angular slip velocities corresponding to the range from 0 to v_2, line c could be used to determine new values of m and μ_0.

Example: Let $\Omega_1 = 4000$ rpm $= 419$ rad/sec; $\Omega_2 = 2000$ rpm $= 209$ rad/sec; $I_1 = 4.36$ lb-in.-sec^2; $I_2 = 17.44$ lb-in.-sec^2; $\mu_0 = 0.121$; $m = 10^{-4}$; $R_o = 2.60$ in.; $R_i = 1.96$ in.; $P = 1500$ lb; $n = 8$ (4-plate clutch); friction area $= 13.93$ sq in. (per side of plate); total friction area of clutch $= 111.44$ sq in.; $T_E = 1200$ lb-in.; and $T_R = 960$ lb-in.

Then

$$T_o = 0.121(1500)(8)(2.28) = 3310 \text{ lb-in.}$$

$$\beta = (0.25 \times 10^{-4})(1500)(2.08)(10)(80) = 6.24 \text{ lb-in./rad/sec}$$

$$\delta = 6.24(21.8/76) = 1.79$$

From these values, $\omega_1(t)$ and other variables become

$$\omega_1(t) = 419 + 11.0t - 108.8(e^{1.79t} - 1) \text{ rad/sec}$$

$$\omega_2(t) = 182 + 11.0t + 27.2e^{1.79t} \text{ rad/sec}$$

$$q_o(t) = 0.1146e^{1.79t} - 0.111e^{3.58t} + 0.394 \text{ Btu/sec/sq in.}$$

$$\frac{d\omega_1}{dt} = 11.0 - 193.5\,e^{1.79t} \text{ rad/sec}^2$$

$$\frac{d\omega_2}{dt} = 11.0 + 48.8\,e^{1.79t} \text{ rad/sec}^2$$

The duration of slip period can be obtained by equating $\omega_1(t)$ and $\omega_2(t)$ and solving for t_o, or it can be determined from the equation

$$t_o = \frac{1}{\delta} \log_e \frac{B_1 - B_2}{\delta(A_1 - A_2) + (B_1 - B_2)} \quad (44)$$

In this example:

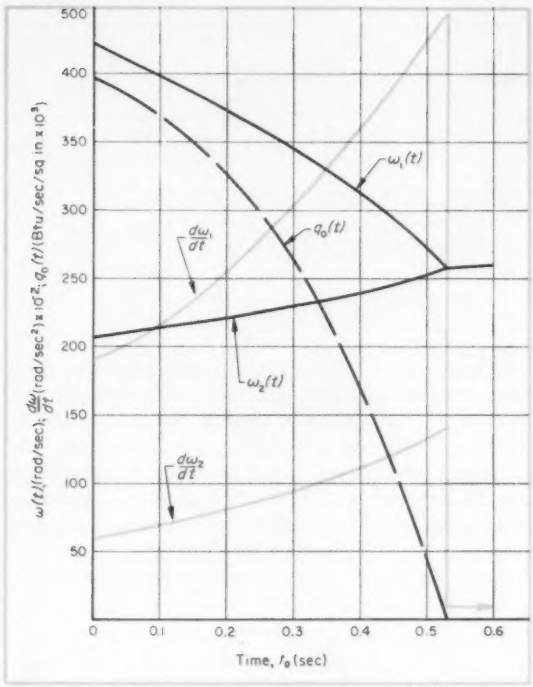


Fig. 12—Change of angular velocity, angular acceleration, and rate of energy dissipation during clutch-engagement period

$$t_0 = 0.56 \log_e \frac{2158}{848} = 0.53 \text{ sec}$$

These results are plotted in Fig. 12.

It should be noted that, due to exponential variation of angular velocity with time (caused by decreasing friction with speed), accelerations of both shafts are much higher and more severe than they would be if the coefficient of friction were independent of rubbing velocity. This observation is important when resulting stresses are considered.

Shunted Clutches

In practice, cases frequently occur where a clutch is not placed directly in the power flow path from prime mover to load, but is shunted by a fixed ratio gear set. In such systems, the designer must consider the effect of the gear ratio on clutch dimensions, and design the clutch according to required thermal and mechanical capacity. A transmission that provides two speeds forward and one reverse, widely used in automotive products, illustrates the following analysis.

Planetary Shunt: The gear set in Fig. 13 is a compound planetary type with two sun gears and one ring gear. "Low" gear is obtained by applying brake band I_1 which holds sun gear S_1 stationary. The reaction force is supplied by a hydraulic cylinder. To obtain "direct" gear, band I_1 is released while the clutch, also actuated hydraulically, is applied simultaneously. This action causes all planetary members to rotate at the speed of the input sun gear S_2. With the brake band I_2 applied and all other control elements released, the planet carrier revolves in a direction opposite to input.

It is seen from Fig. 13 that at $t = 0$ (beginning of transition from low to direct), the relative angular velocity between the clutch plates is equal to engine speed at that time. But the torque impressed on the clutch is equal to a fraction of input torque. The exact value of torque impressed is determined by the gear ratio.

Since it is assumed that the disappearance of the reaction force on S_1 and energization of the clutch are instantaneous and occur simultaneously (a con-

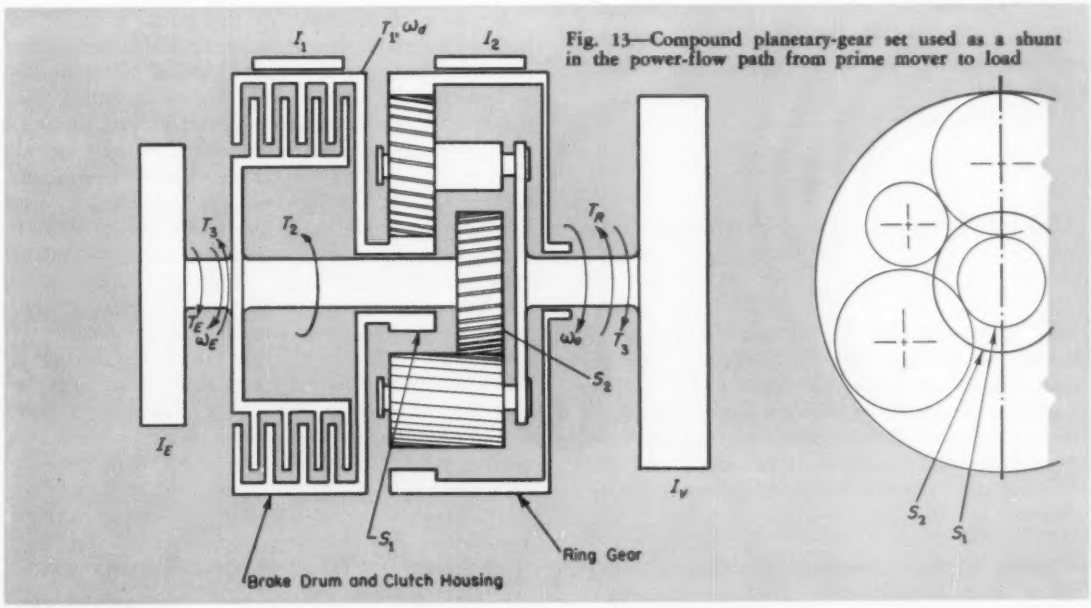


Fig. 13—Compound planetary-gear set used as a shunt in the power-flow path from prime mover to load

dition closely approximated in practice), the only external torques acting on the system at $t = 0$ are engine torque T_E and road load torque T_R.
Thus,

$$\text{Torque in input shaft} = \text{torque in output shaft} = T_3$$

As is usually the case in practice, the moments of inertia of the clutch housing and the ring gear are negligible in comparison with the equivalent inertia of the vehicle I_V and the engine inertia I_E. Then

$$T_3 = T_1 + T_2 \tag{45}$$

The basic gear ratio, g, is defined as: No. of teeth in S_1/No. of teeth in S_2. Then the following expression results

$$T_1 = g\,T_2 \tag{46}$$

Therefore, from Equations 45 and 46,

$$T_3 = \left(1 + \frac{1}{g}\right) T_1 \tag{47}$$

$$T_2 = \frac{1}{g}\,T_1 \tag{48}$$

The following equations describe the system in transition from low to direct:

$$I_E \frac{d\omega_E}{dt} = T_E - \left(1 + \frac{1}{g}\right) T_1 \tag{49}$$

$$I_V \frac{d\omega_o}{dt} = T_1 \left(1 + \frac{1}{g}\right) - T_R \tag{50}$$

To find an expression for relative velocity of clutch plates, an examination is made of the relationship between speeds of various members of the planetary gear system. Thus, the relative velocity of the sun gear S_2 to the planet carrier is $\omega_E - \omega_o$, and that of sun gear S_1 in relation to the carrier is $\omega_d - \omega_o$.
The ratio of these two relative velocities must at any time be equal to the ratio g. Thus,

$$\frac{\omega_E - \omega_o}{\omega_d - \omega_o} = -\,g \tag{51}$$

The negative sign in Equation 51 indicates that these two velocities are always opposite in direction to each other.
From Equation 51,

$$\omega_d = \frac{(g+1)\omega_o - \omega_E}{g}$$

Then the relative clutch plate velocity is

$$\omega_r = \omega_E - \omega_d = \left(1 + \frac{1}{g}\right)(\omega_E - \omega_o) \tag{52}$$

Note that equations 49, 50, and 52 are exactly the same as the equations for a simple two rotor system, Fig. 10, except for the factor $1 + 1/g$. They are sufficient to solve any problem concerning speeds, accelerations, and torques acting on various members of the system during the transition period, provided clutch torque remains independent of the slip velocity.

Varying Friction Considered: If the coefficient of friction varies linearly with speed, for the engine side of the clutch,

$$I_E \frac{d\omega_E}{dt} = T_E - \left(1 + \frac{1}{g}\right) T_o + \left(1 + \frac{1}{g}\right)^2 \beta(\omega_E - \omega_o) \tag{53}$$

Similarly, for the output side of the clutch,

$$IV \frac{d\omega_o}{dt} = \left(1 + \frac{1}{g}\right) T_o - \left(1 + \frac{1}{g}\right)^2 \beta(\omega_E - \omega_o) - T_R \tag{54}$$

Examination of Equations 53 and 54 shows that, when rearranged, they are the same as Equations 36 and 37 set up for a simpler system containing only one power path. Solutions for speeds and rate of energy dissipation obtained from Equations 36 and 37 are applicable in the case of the transmission system in Fig. 13, provided that in evaluating pertinent constants, T_o and β are written

$$T_o' = \left(1 + \frac{1}{g}\right) T_o \tag{55}$$

$$\beta' = \left(1 + \frac{1}{g}\right)^2 \tag{56}$$

It can be seen from the above discussion that any complicated transmission system containing a friction clutch can be transformed to a much simpler one which is easier to analyze. In general, the constant g occurring in preceding equations can be expressed as the ratio

$$g = \frac{\text{Speed of input side of clutch}}{\text{Speed of output side of clutch}} \tag{57}$$

when it is computed for the case when the output shaft of the complete transmission system (or of a given part of it containing the clutch) is stationary. This holds true regardless of the type of the gear set used.

Accuracy of Analyses: At this point, it might be well to question the accuracy of results from the preceding analyses. In reality, few of the equation constants will remain truly constant during the clutching operation. Engine output torque, the friction-speed characteristic of the clutch facing material, axial force P acting on clutch plates—all will undoubtedly vary during the operation of a clutch. In many cases, the functional relationship between these quantities and time, and/or speed, cannot be expressed mathematically. The only information readily available is in performance tables or graphs.
If it is expected that variation in the parameters mentioned will influence the result of calculations using the equations developed here, it is suggested that the finite difference method be used for computation purposes. It is observed, however, that this method results in solutions to one specific problem only, for a specific set of values of different parameters. Thus, by using the finite difference method one cannot, by examining results, predict the effect of changing any or all of the parameters on the over-all system performance.

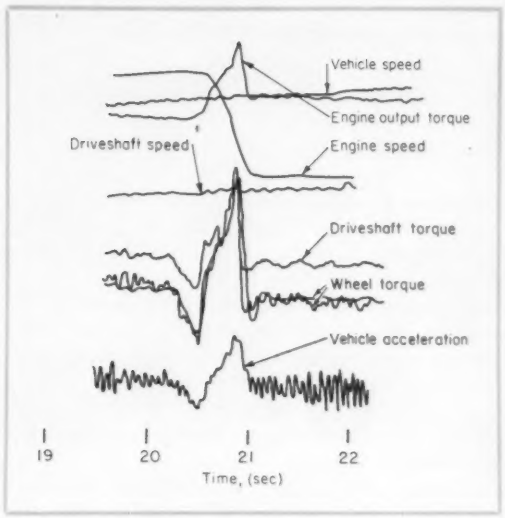


Fig. 14—Oscillographic recording of an upshift in a passenger-car automatic transmission

Fig. 14 is an oscillographic record of input and output speeds and torques taken during the automatic shift in an automobile. The recording shows that the action of the clutch causes a significant change in engine speed with consequent loss of considerable kinetic energy. The amount of this energy is about 3×10^4 lb-ft. Some is dissipated in the clutch in the form of heat, and some is transmitted through the driveline and shows up as a sudden increase in output torque. Since all this occurs in a short time (0.5 to 0.7 sec), the resulting impact and shock loads on the transmission and driveline parts may become quite appreciable, and their effects may be damaging.

Additions of Inertia

Consider the system in Fig. 13. To cancel the effect of engine inertia energy released during the transition, it is possible to place an additional inertia at some point in the system between the input and output shafts. The added inertia could be accelerated during the shift, and would absorb the kinetic energy lost by the engine.

Location of Added Inertia: Since the subject at this point is inertia effect, the action of engine and load torques can be neglected. Consider the system in equilibrium with no external forces acting on it. One convenient point for the shocking-absorbing inertia is the output side, which is stationary before the clutch is applied, Fig. 15. With this added inertia, the torque acting on the sun gear S_1 has two components, namely,

$$T_1 = T - I_d \frac{d\omega_d}{dt} \tag{58}$$

where I_d = inertia in the output side of clutch, ω_d = angular velocity of output side of clutch, and T = frictional clutch torque.

Torque distribution in the planetary system is such that the torque in the planet carrier (output) is

$$T_o = \left(1 + \frac{1}{g}\right) T_1 \tag{59}$$

Observe that when $T = I_d\, d\omega_d'$, T_o is zero. Therefore, no inertia torque due to change in kinetic energy of the engine will appear in the output shaft, and the transition from one speed to the other will be free of shock.

Note that I_d is the effective moment of inertia of all parts referred to the output side of the clutch that must be accelerated by clutch torque T. The inertia of planets and ring gear must not be overlooked.

Amount of Added Inertia: The value of I_d required to have a shockless transition must be determined. If linear variation of speeds with time is assumed, conditions existing during transition are shown in Fig. 16.

In the system under consideration,

$$\Omega_E = (1 + g)\Omega_o \tag{60}$$

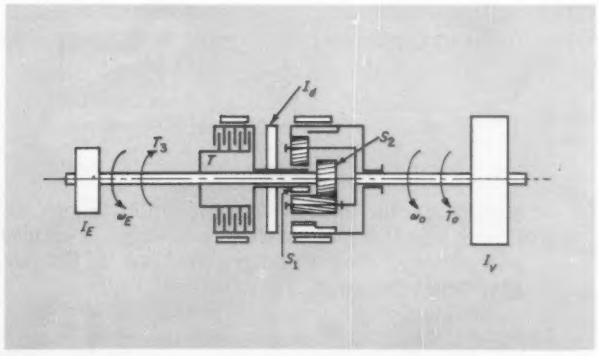


Fig. 15—Shock-absorbing inertia member added to the output side of a power-transmission system containing a compound planetary-gear set

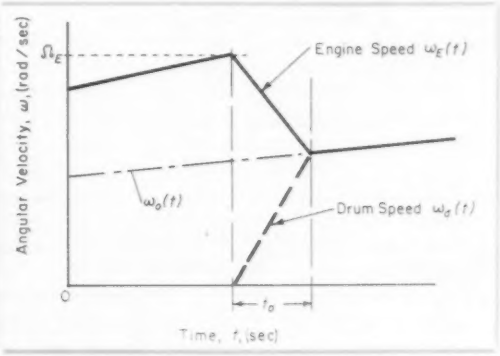


Fig. 16—Linear changes of speed with time during clutch engagement while system accelerates

Since the output shaft does not change speed during the time interval under consideration, and there are no torques acting on the gear set, it can be dispensed with entirely. Then I_d is equal to I_2, as in Fig. 8.

It can be verified that regardless how speeds vary with time, the following expression represents the kinetic energy given up by the engine during transition:

$$E_e = \frac{1}{2} I_E(\Omega_E^2 - \Omega_o^2) \qquad (61)$$

This must be equal to the energy gained by the inertia I_d plus the energy dissipated in the clutch during the transition period. The latter can be obtained from Equation 33. The energy balance equation is

$$\frac{1}{2} I_E(\Omega_E^2 - \Omega_o^2) = \frac{1}{2} I_d \Omega_o^2 + \frac{1}{2}\left[\frac{I_E I_d(\Omega_E - \Omega_o)^2}{I_E + I_d}\right] \qquad (62)$$

Substitution for $\Omega_o = \Omega_E/(1 + g)$ and solution of the resulting quadratic equation for I_d yield

$$I_d = \frac{1}{2} I_E [(4g^2 + 8g + 1)^{1/2} - 1] \qquad (63)$$

Example: With $I_E = 0.46$ lb-ft-sec^2 and $g = 0.63$, the value of I_d for the system in Fig. 15 is:

$$I_d = \frac{1}{2}(0.46)\,[(4 \times 0.63^2 + 8 \times 0.63 + 1)^{1/2} - 1]$$

$$= 0.405 \text{ lb-ft-sec}^2$$

Therefore, a solid cylinder 9.0 in. in diameter and 10 in. long would be necessary to supply added inertia to the system of Fig. 15 to make the transition shockless.

Observations: This example illustrates that the method of obtaining a smooth shift from one ratio to the other by placing an inertia in a proper point in the transmission can be considered only in cases where weight and/or size is not a design problem, or where the value of engine inertia and basic gear ratio are relatively small.

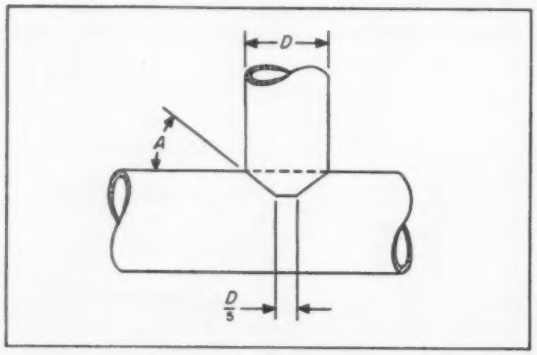
For heavy off-the-road vehicles and stationary power transmission systems, this method should prove to be useful, especially where the flywheel I_d can be made large in diameter.

The next article in this series shows how to forecast the temperatures imposed on friction surfaces, how to determine temperature limits for friction materials, and how to make the two compatible.

Tips and Techniques

Saddle Cuts in Pipe

Layout of cuts for right-angle joint welds in standard pipes is an involved procedure. This problem is simplified by the following table which gives the required angle of cut, *A*, for different pipe sizes.



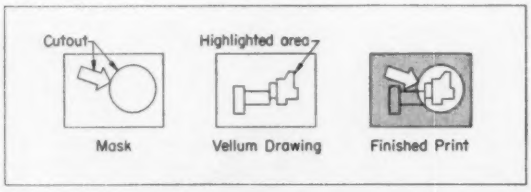
Values of Cut Angle, *A* (deg)

Through Pipe Size (in.)	Branch Pipe Size, *D* (in.) 2	1½	1¼	1	¾	½
½	—	—	—	—	—	36
¾	—	—	—	—	37	24
1	—	—	—	38	26	19
1¼	—	—	39	26	20	
1½	—	39	30	18		
2	40	28	23			
2½	30	22				
3	23					

As shown in the figure, width across the bottom of cut is $D/5$, where D is the branch pipe diameter. Although this method is approximate, it is close enough for most practical purposes.—Jesse G. McCune, *Kansas City, Mo.*

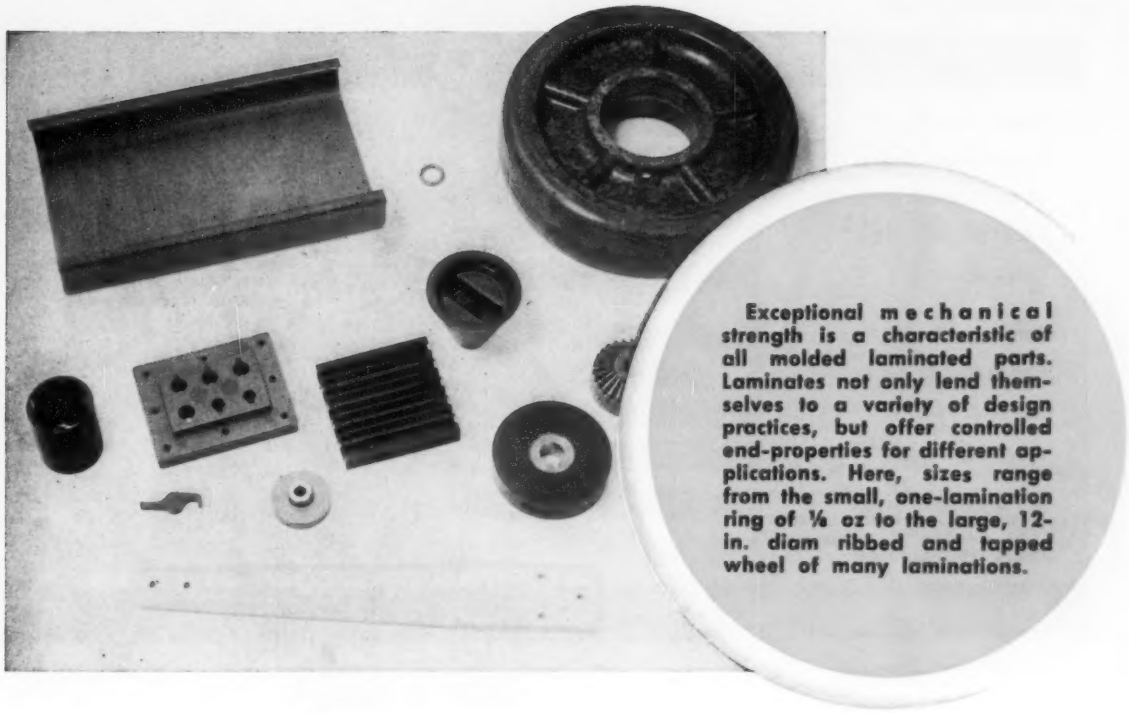
Emphasizing Drawings

Tracing paper can be used to emphasize certain parts of drawings that are reproduced by an Ozalid machine. Cut a mask from tracing paper and tape to back of drawing, using a dull-finish translucent



tape. When the masked drawing is run through the Ozalid machine, the masked area appears shaded and the required area remains vivid.—A. B. Cistola, *IBM Corp., Owego, N. Y.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, Machine Design, Penton Bldg., Cleveland 13, O.



Exceptional mechanical strength is a characteristic of all molded laminated parts. Laminates not only lend themselves to a variety of design practices, but offer controlled end-properties for different applications. Here, sizes range from the small, one-lamination ring of ⅛ oz to the large, 12-in. diam ribbed and tapped wheel of many laminations.

Design requirements for

Molded Laminated Plastic Parts

By **RICHARD BICE,** Assistant Product Engineer, Formica Corp., Cincinnati, Ohio

MOLDED laminated parts are made from layers of resin-treated filler materials formed in a mold under heat and pressure. Available combinations of resins and fillers offer designers a means of custom building a material for specific applications rather than merely selecting one. Although properties of these laminated plastics can be controlled to meet application requirements, the characteristic of exceptionally high mechanical strength is always present in the part.

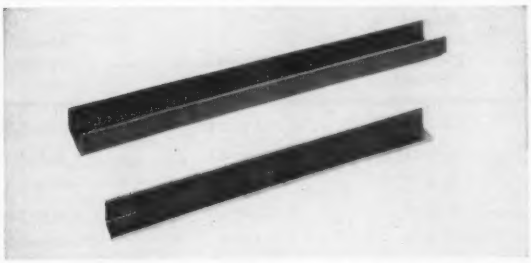


Fig. 1—Paper-phenolic laminates for electrical applications. This combination can be machined to a good surface finish, is economical, and has a fair degree of mechanical strength

These laminates are somewhat similar to molded reinforced parts. The basic difference is that fillers, in the form of sheets or mats rather than chopped fibers, are resin treated and dried prior to use. Also, laminated parts are molded under higher pressures and temperatures, which impart a higher density and generally improved surface finish.

Resins: Thermosetting resins are used exclusively for molded laminated parts. Phenolics, melamines, silicones, and epoxies form the bulk of these materials and are often combined to achieve special properties. While characteristics of these resins overlap to some extent, each has certain advantages.

In general, phenolics are used for chemical and mechanical applications, melamines for ordinary electrical applications, silicones for high tempera-

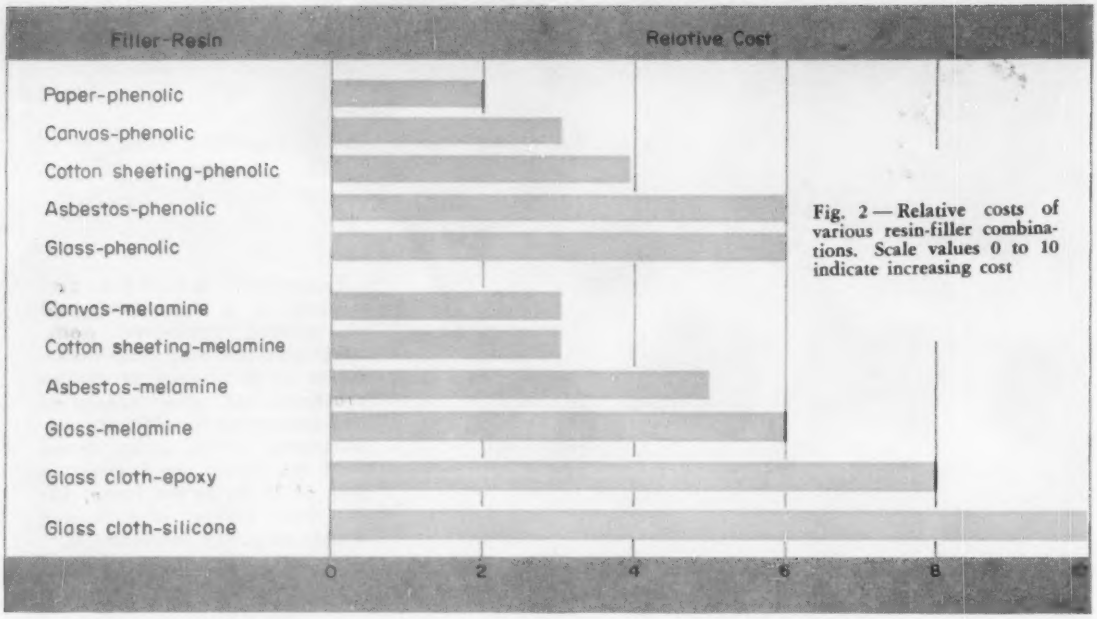


Fig. 2 — Relative costs of various resin-filler combinations. Scale values 0 to 10 indicate increasing cost

tures, and epoxies for maximum electrical characteristics. Properties of laminated phenolic sheets are shown in Table 1.

Fillers: Paper, canvas, cotton, asbestos, and glass are generally used as filler materials. The continuous-fiber structure inherent in these materials is responsible for the physical strength that characterizes molded laminated parts.

Choice of a laminating material is dictated by the application. Paper can be employed successfully in most electrical applications and is usually the cheapest. It possesses a fair amount of mechanical strength, can be formed into simple shapes such as channels and angles, and can be machined to a good surface finish, Fig. 1.

Canvas and cotton sheeting have qualities similar to paper but provide greater mechanical strength and formability. They are more suitable for complicated shapes since they have less tendency to tear.

Asbestos is used for laminations when the part must have a higher degree of heat resistance than is possible with paper or canvas. The choice between cloth or mat is largely dictated by the form of the finished product.

Glass imparts a high degree of strength to the finished product and will not, in itself, support combustion. Since glass cannot absorb water, it will not support fungus growth, and humidity conditions will not change its size. However, glass is heavier than other fillers.

Resin and Filler Combinations: Each combination is engineered for a particular application. If a part is required for electrical insulation, paper laminations with an electrical grade of resin are used. Addition of a lamination of copper on one or both sides of the paper assembly makes the part suitable for etched circuitry. For difficult electrical requirements, glass cloth and epoxy resin are used.

When a part is to be used in chemical environments, canvas laminations with phenolic resins pro-

Table 1—Properties of Laminated Phenolic Sheets

Filler Material	Tensile Strength (1000 psi)	Compressive Strength (1000 psi)	Flexural Strength, Flatwise (1000 psi)	Impact (ft-lb/in. of notch)	Specific Gravity
Paper	9 to 18	22 to 36	15 to 23	0.4 to 1.1	1.34 to 1.38
Canvas	8 to 10	31 to 44	14 to 21	1.5 to 2.8	1.33 to 1.38
Cotton sheeting	8 to 16	34 to 39	14 to 21	1.2 to 1.6	1.2 to 1.5
Asbestos	8 to 10	35 to 38	16 to 22	1.3 to 4.0	1.55 to 1.58
Glass cloth	11 to 21	45 to 50	22 to 24	7 to 8	1.65 to 1.7
General-purpose compounds	6.5 to 9	24 to 36	9 to 12	0.24 to 0.34	1.32 to 1.55

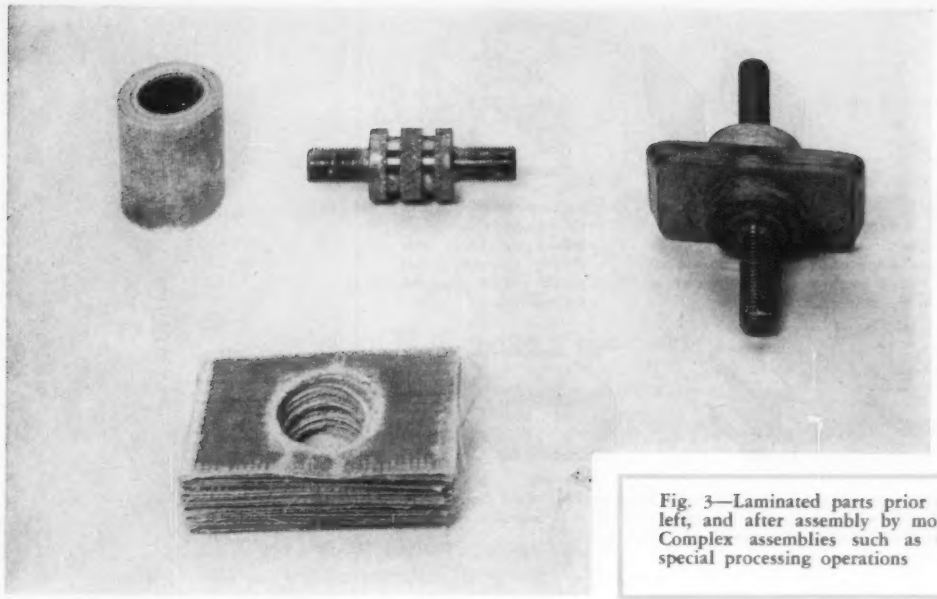


Fig. 3—Laminated parts prior to assembly, left, and after assembly by molding, right. Complex assemblies such as this require special processing operations

vide necessary qualities. For aircraft applications, the combination might be glass cloth and a melamine resin. Here, the glass provides strength and fungus resistance. The melamine resin possesses good electrical and fire-retarding properties. A comparison of general properties of various resin-filler combinations is shown in Table 2.

Although it is possible to provide a combination of resin and filler to suit most applications, there are certain limiting factors to consider. Glass materials are highly abrasive, and tool life is short where extensive machining is required. Paper and canvas possess excellent machining characteristics but are subject to size changes due to humidity conditions. This must be considered when establishing tolerances.

Costs vary with laminate combinations from the low-cost paper-phenolic to the most expensive glass-silicone, Fig. 2.

Design Considerations: Choice of filler and resin in specific applications depends on how the part will be used, where it will be used, and properties required. Where the part is used is often very important. For example, silicone materials are very good for applications where a high degree of heat resistance is required. However, they deteriorate rapidly in the presence of oil, grease, or gasoline.

Proper design is essential since laminated plastics do not adopt themselves to complex forms as readily as chopped-filler types. One rule of thumb may be applied for simple forms such as angles and channels: If the part can be formed from a piece of paper without tearing, it can be molded readily from laminated plastics. More complex forms may require special treatment such as punching or die cutting to shape, rolling, or other processing operations, Fig. 3.

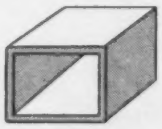
Although extra material can usually be built up where needed, uniform wall-thickness is preferable. Fillets and draft angles are handled in the same way as for any molded part. In general, tolerances

Table 2—Relative Ratings of Laminated Filler-Resin Materials*

Filler-Resin Combination	Insulating Property	Resistance to			Mechanical Strength	Dimensional Stability		Machinability
		Acid	Alkali	Heat		Moisture	Temperature	
Paper-phenolic	1 to 3	0 to 3	0 to 2	1 to 3	1 to 5	1 to 5	2 to 5	4 to 6
Canvas-phenolic	1 to 2	3 to 6	1 to 7	2 to 4	2 to 4	1 to 5	1 to 5	6 to 8
Cotton sheeting-phenolic	1 to 3	1 to 6	1 to 7	3 to 4	2 to 4	1 to 5	2 to 4	7 to 9
Asbestos-phenolic	0 to 1	0 to 3	1 to 3	7 to 8	2 to 4	5 to 7	8 to 9	1 to 4
Glass cloth-phenolic	1	4 to 6	3	8 to 9	6	7	9 to 10	1 to 2
Canvas-melamine	2	1	8	2	4	—	—	—
Cotton sheeting-melamine	1	4	2	5	5	—	—	—
Asbestos-melamine	0 to 1	0 to 3	1 to 3	7 to 8	2 to 4	—	—	—
Glass cloth-melamine	1 to 2	2	4	5	8 to 9	—	—	—
Glass cloth-epoxy	10	4	5	6	10	—	—	—
Glass cloth-silicone	2	8	2	10	4	—	—	—

*Scale 0 to 10 shows relative minimum to maximum values.

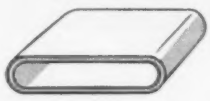
Standard forms of laminated channel sections. Recommended minimum internal corner radius is 1/64 in. Outer corner radius should equal inner corner radius plus wall thickness. Angle of sidewall to base will not remain constant in any unrestrained condition due to strains inherent in the molding.



A sharp-corner condition. Configuration may be attained by finish machining operations, but should not be designed for molding.

Methods of handling unequal wall thicknesses. When possible, parts should be designed for uniform wall thicknesses throughout. Buildup of material usually calls for special consideration of die and tooling problems.

Use of chopped material to supplement the laminates. This constitutes good design practice in that it permits variations in wall thickness without complicated laminate buildups. Many "impossible" designs are practical with this technique.



Typical electrical-insulator shape.

Basic Design Shapes for Molded Laminated Parts (Fig. 4)

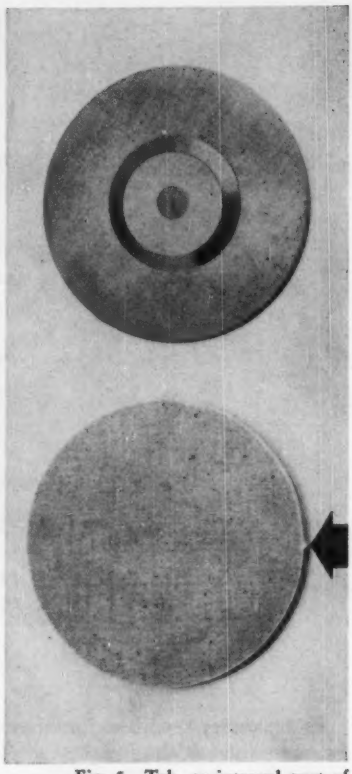


Fig. 5—Tab, as integral part of the molded piece, permits alignment of laminations to reduce or prevent assembly warpage

conform to the same requirements as in normal molding practice. Recommendations for handling design configurations are shown in Fig. 4.

The extra strength of laminated construction and good qualities as a bearing material frequently eliminate the need for inserts. Ribs and bosses can be built into molded parts when necessary. However, the inherent strength of laminated materials frequently eliminates need for ribs. Where there is danger of warp in an assembly, proper alignment of laminations will usually reduce this to a minimum, Fig. 5. When holes are required, design configuration and hole tolerances dictate whether the hole should be molded, drilled, or punched.

Raised or indented lettering can be molded on parts with no difficulty. Where such lettering is merely for part identification, the same objective can be accomplished with a rubber stamp. The stamp method is preferred when changes are frequent.

When necessity dictates, laminated fillers can be used in combination with chopped fillers, Fig. 4. In this manner, designs can be achieved which are impossible or impractical with laminated or chopped fillers alone. Additional rules for good design of laminated parts are:

1. Box-shaped sections, having ends as well as sides and bottoms, are not producible except under very ideal conditions. Such sections must have very shallow depths or draw and very generous radii in corners.
2. Irregular parting lines should be avoided to eliminate excessive finishing operations.
3. Sharp corners, other than those produced in a finishing operation, should be avoided to protect tooling rather than because of a limitation in the material.
4. Conventional methods of milling, drilling, planing, boring, sawing, tapping, and other subsequent machining operations should be specified for laminates. Grade of material, finish required, and quantity of parts, will determine type of tools used. High-speed steel, carbide, and diamond tools can be used successfully. Sawing operations on glass are best accomplished with abrasive wheels, using coolant if considerable work is done.

Molding: Matched dies are used for molding laminated plastics. Pressures vary from 1500 to 15,000 psi. When the part has a simple shape and the production run is small, it may be practical to use unhardened or prehardened cavities. If production is high or the part requires material trimming, molds are usually hardened. Laminated materials are usually processed in flash-type or positive-type molds. With the exception of shrinkage effects, the molded material exerts no influence on design of tooling. A mold produces parts from paper, canvas, or glass laminates with equal facility.

Surface finish also depends on product requirements and can range from a smooth, sanded finish to a mirror finish.

FOUR-BAR
Function Generators

. . . tables for finding the proportions of linkages that generate common mathematical functions with minimum error

By FERDINAND FREUDENSTEIN
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Columbia University
New York, N. Y.

A NUMBER of problems in design involve the synthesis of a mechanism with input and output members rotating in a prescribed relationship. Typical examples include:

1. Mechanical linearizer.[1, 2]
2. Radio tuning mechanisms.[3]
3. Nonlinear rotary valve actuators.
4. Controlled acceleration drives such as the shuttles in a textile loom.
5. Computing components of analog computers.[4]
6. Constant angular-velocity-ratio shaft couplings.[5, 6]
7. Quick-return mechanisms and mechanisms with constant-velocity drive motion.[7]
8. Linkages and mechanisms having momentary dwells.[8]
9. Tuning mechanisms for klystrons.
10. Linkages to replace cams with rotary input and output, especially in heavy duty and high-speed applications.

[1]References are tabulated at end of article.

This article is based on a paper presented at the Fifth Conference on Mechanisms, Purdue University, October 13-14, 1958.

The simplest mechanism which can accommodate such requirements and still permit reasonable flexibility in design is the four-bar linkage *ABCD*, Fig. 1. Recently developed analytical techniques[9] and the availability of large-scale digital computers have made it possible to compute the proportions of four-bar mechanisms, known as function generators, in which the rotations of the driving crank and driven link are related by a prescribed or ideal function.

Generally, due to the finite number of adjustable linkage proportions, the function generated by the mechanism coincides with the ideal function only at a finite number of points, called precision points, and deviates from the ideal function between these points. This deviation is called the

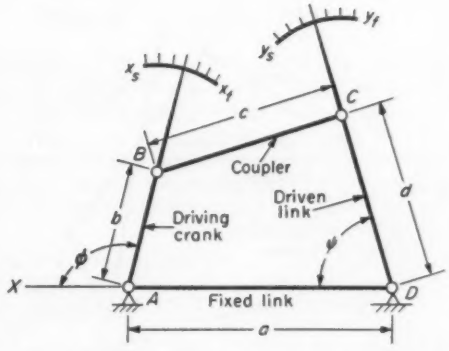


Fig. 1—General form of four-bar function generator

Nomenclature

a = Length of fixed link, Fig. 1
b = Length of crank or driving link, Fig. 1
c = Length of coupler link, Fig. 1
d = Length of driven link, Fig. 1
$f(x)$ = Ideal function
$g(x)$ = Function generated by mechanism
r_ϕ = Input scale factor
= $(\phi_f - \phi_s)/(x_f - x_s)$
r_ψ = Output scale factor
= $(\psi_{max} - \psi_{min})/(y_{max} - y_{min})$
$x_1, x_2 \ldots x_i$ = Precision points at which $f(x_i) = g(x_i)$
x_f = Upper-limit (finish) point of crank travel, Fig. 1
x_s = Lower-limit (start) point of crank travel, Fig. 1
ϕ = Angle of rotation of input shaft, Fig. 1, measured clockwise, radians
ψ = Angle of rotation of output shaft, Fig. 1, measured clockwise, radians

Table 1—Least-Error

Function y	Range $x_s \leqq x \leqq x_f$	Scale Factors r_ϕ	r_ψ	Precision Points x_1	x_2	x_3	x_4	x_5
$\log_{10}x$	$1 \leqq x \leqq 2$	60	$60/\log_{10}2$	1.0144678	1.1355580	1.3842742	1.7104985	1.9627009
$\sin x$	$0 \leqq x \leqq 90$ deg	1	90	2.7633673	21.988925	48.226892	71.414168	87.549520
$\tan x$	$0 \leqq x \leqq 45$ deg	2	90	1.6246052	12.842451	27.476764	38.542302	44.269088
e^x	$0 \leqq x \leqq 1$	90	52.377904	0.02781610	0.19327052	0.49740748	0.79659339	0.97582616
$1/x$	$1 \leqq x \leqq 2$	90	180	1.0130385	1.1561093	1.4991776	1.7984797	1.9786677
$x^{1.5}$	$0 \leqq x \leqq 1$	90	90	0.011835966	0.14032685	0.40993302	0.74496432	0.97026835
x^2	$0 \leqq x \leqq 1$	90	90	0.033689272	0.24917564	0.54280174	0.81636273	0.97863119
$x^{2.5}$	$0 \leqq x \leqq 1$	90	90	0.022529458	0.21794875	0.54157659	0.81866346	0.97795758
x^3	$0 \leqq x \leqq 1$	90	90	0.029325922	0.25920673	0.58821332	0.84128244	0.98093850
x^2	$-1 \leqq x \leqq 1$	45	60	−0.9452	−0.5259	0.0492	0.6728	0.9767

Fig. 2—Development of a four-bar linkage with a logarithmic input-output relationship to control operation of a mixing valve in a blending process

Problem: Blending in a chemical process is to be controlled by a rotary mixing valve which has linear flow characteristics and a total operating range of 60 deg. To meet process requirements, valve movements must be proportional to the logarithm of the absolute temperature, which may range from 492 (32 F) to 860 (400 F). Electric signals from the sensing thermocouple are converted into a shaft rotation proportional to temperature. Maximum shaft travel is 60 deg. Design a four-bar linkage to provide the required control function.

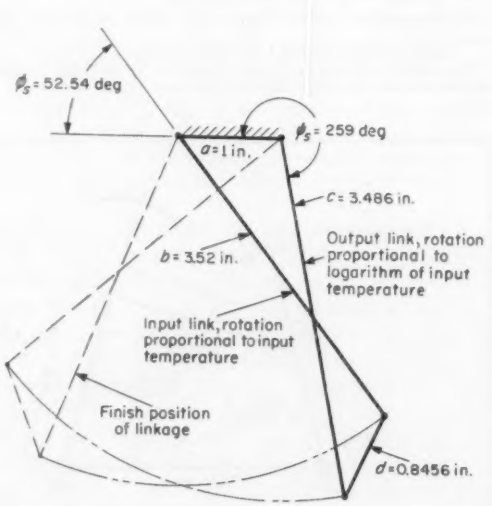
Solution: From the given data, input range (shaft rotation) is 60 deg and output range (valve travel) is 60 deg.

Ideal function to be generated by linkage is

$$y = \log_{10}\left(\frac{T + 460}{460}\right), 0 \leqq T \leqq 460$$

$$= \log_{10} x, 1 \leqq x \leqq 2$$

where T = temperature, F, x = temperature, F absolute, divided by 460 and y = output signal. For this application, the range indicated is slightly larger than required.


ϕ_s = 52.54 deg
ϕ_s = 259 deg
a = 1 in.
c = 3.486 in.
b = 3.52 in.
Output link, rotation proportional to logarithm of input temperature
Input link, rotation proportional to input temperature
Finish position of linkage
d = 0.8456 in.

Five-Point Function Generators

Link Angles (deg) ϕ_1	ψ_1	Link Proportions b/a	c/a	d/a	Maximum Output Error (deg)	(% of output travel)	Remarks
52.628390	259.07749	−3.3523485	0.84560215	3.4855187	0.0037 ± 0.0001	0.0062	Negative lengths are interpreted vectorially.
−62.263261	75.606709	1.8343688	2.2385439	−0.69364556	0.1900 ± 0.0002	0.21	Usable as resolver; also as cosine.
269.70917	124.18966	−2.6603189	7.4304440	8.6856194	0.038 ± 1 %	0.042	By reversing terminals any linkage can generate $y = f^{-1}(x)$, which gives $y = \tan^{-1} x$ here.
241.64463	40.422765	−3.4994859	0.87854083	3.3993445	0.0258 ± 1 %	0.0287	
33.804400	120.21283	−0.38477780	1.0305418	0.38453884	0.0161	0.0179	6 precision points, error not minimized.
−5.1709711	211.68878	0.62481545	1.3088626	−0.40060612	0.146 ± 1 %	0.162	See Table 2 also for another solution.
−29.320664	233.83630	2.5233585	3.3295928	−0.55594832	0.0673 ± 1 %	0.0748	Has constant acceleration, usable also for $y = x^{1/2}$.
−88.314667	44.492538	−1.8009087	0.90829808	1.2737203	0.412 ± 1 %	0.457	
−85.921508	37.636724	−1.6056207	0.92537009	1.1073831	0.5095 ± 1 %	0.566	Usable also for $y = x^{1/3}$.
−21.18	−53.67	−0.6102	0.5656	0.3804	2.34 ± 15 %	4.47	Constant acceleration, used also in multipliers.

Required input scale factor is:

$$r_\phi = \frac{\text{Range of input}}{\text{Range of } x} = \frac{60 \text{ deg}}{2 - 1} = 60 \text{ deg per unit } x$$

Required output scale factor is:

$$r_\psi = \frac{\text{Range of output}}{\text{Range of } y} = \frac{60 \text{ deg}}{\log_{10} 2} = \frac{60}{\log_{10} 2} \text{ deg per unit } y$$

From Table 1, a linkage that satisfies the range and scale-factor requirements for this application is given in the top line. If a suitable linkage had not been tabulated, it would have been necessary to compute one using the computer program mentioned in the text of the article.

Starting position of the linkage selected for this application can now be determined:

$$\phi_s = \phi_1 - r_\phi(x_1 - x_s)$$

$$= 52.63 - 60(1.01447 - 1) = 52.54 \text{ deg}$$

$$\psi_s = \psi_1 - r_\psi(y_1 - y_s)$$

$$= 259.077 - \frac{60}{\log_{10} 2} (\log_{10} 1.0144) \approx 259 \text{ deg}$$

Link dimensions can be calculated from the proportional relationships given in the table. Governing dimension is a. If $a = 1$ in., the required linkage, with links in the starting position, is shown in the sketch.

For integration of the linkage with the valve assembly, two operating relationships can be established. Input temperature is given by

$$T = \frac{460}{60} (\phi - 52.54)$$

where T = input temperature, F. Output motion of valve, ψ, can be found from

$$\psi - 259 = \frac{60}{\log_{10} 2} \log_{10} \left(\frac{T}{460} + 1 \right)$$

The whole mechanism must thus be zeroed and set to conform with these conditions.

From Table 1, maximum error in the output angle, ψ, will be 0.0037 deg.

Table 2—Five, Six and

Function y	Range $x_a \leqq x \leqq x_f$	Scale Factors r_ϕ	r_ψ	Precision Points x_1	x_2	x_3	x_4	x_5
$-\log_{10}x$	$1 \leqq x \leqq 2$	60	$60/\log_{10}2$	1.02447	1.20611	1.50000	1.79389	1.97553
$-\log_{10}x$	$1 \leqq x \leqq 2$	60	$60/\log_{10}2$	1.0166537	1.1384432	1.3704083	1.6816018	1.9567889
$-\log_{10}x$	$1 \leqq x \leqq 2$	90	$90/\log_{10}2$	1.0131453	1.1223993	1.3400125	1.6301256	1.9272569
$\log_{10}x$	$0 \leqq x \leqq 10$	60	90	1.000	1.431	2.307	4.190	8.577
$\tanh x$	$0 \leqq x \leqq 1.2$	50	$60/\tanh 1.2$	0	0.1	0.3	0.6	1.2
$x^{1.5}$	$0 \leqq x \leqq 1$	90	90	0.011786952	0.14019032	0.40974073	0.74490330	0.97020681
Ackerman steering linkage type	.....	..	....	-24.133 [ϕ_1] -30 [ψ_1]	-13.295 [ϕ_2] -15 [ψ_2]	0 [ϕ_3] 0 [ψ_3]	15 [ϕ_4] 13.295 [ψ_4]	30 [ϕ_5] 24.133 [ψ_5]
$E = \int_0^x \sqrt{Z}\,dx$ ($Z = 1 - k^2 \sin^2 x$, $k = 1$)	.....	1	90	10 deg	30 deg	50 deg	70 deg	90 deg

*Maximum error not minimized. †Not computed.

Fig. 3—Typical applications of four-bar function generators

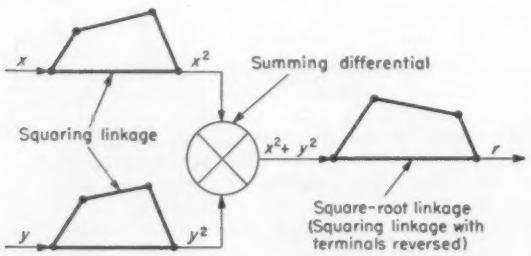
Analog Computation

An operation frequently required in computers involves conversion of Cartesian (x, y) to polar co-ordinates (r, θ). Basic functions with typical ranges are:

$$r = (x^2 + y^2)^{1/2},\ x > 0,\ y > 0$$

$$\theta = \tan^{-1}\left(\frac{y}{x}\right),\ 0 \leqq \theta \leqq 45 \text{ deg}$$

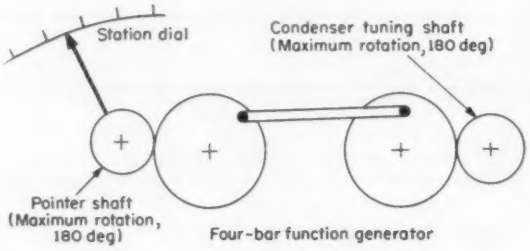
A schematic diagram of the linkage arrangement for the first



conversion is shown in the sketch. The squaring linkage used in this arrangement is given on the seventh line of Table 1. All quantities indicated in the sketch are shaft rotations. The second equation can be mechanized similarly.

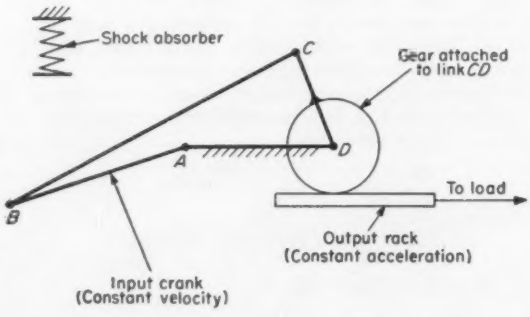
Scale Linearization

In place of the well-known rope drive used in radio-tuning mechanisms, the arrangement depicted in the sketch has been proposed as being more rugged and still economical to produce. Relationship between condenser capacitance and dial movement is nonlinear. It would be possible, for example, to select the five most frequently used stations, and obtain the correct condenser setting exactly with a linkage solved directly from the computer program mentioned in the article text. The intermediate stations would probably still be sufficiently close for satisfactory operation.



Constant-Acceleration Drive

A useful device for developing constant-acceleration characteristics in a linear drive is shown in the sketch. Linkages suitable for this application are given in Table 1, lines 7 and 10. With such devices, a shock absorber or similar device must be provided in the system for braking.



Seven-Point Function Generators*

Link Angles ϕ_1 (deg)	Link Angles ψ_1 (deg)	Link Proportions b/a	Link Proportions c/a	Link Proportions d/a	Maximum Output Error (deg)	Maximum Output Error (% of output travel)	Remarks
61.170006	99.393040	−0.28491374	1.0359560	0.25841210	0.00269	0.00447	6 precision points obtained.
60.041818	100.01252	−0.28723765	1.0344139	0.26145405	0.00121	0.00202	Extra point has vanished.
46.226164	121.84521	−0.19764338	1.0109764	0.19079753	0.006	0.007	
19.372363	−85.964738	−1.2163005	2.8051365	3.1917229	0.382	0.425	
−11.687321	227.31048	−2.0623636	−1.2576833	1.10206535	†		This and the last 2 linkages are included just to show variety of functions obtainable.
−57.297316	97.203550	−5.7825465	3.2790367	2.1766471	0.030	0.033	7 precision points obtained.
178.46532	127.40168	3.1409818	4.7996436	−3.1409818	†		$b = d$ whenever $y = f(x)$ is symmetrical about $x = -y$.
−57.684795	79.532633	1.3903893	1.9488378	−0.55277126	†		Shows complexity of functions which can be handled; E = elliptic integral.

structural error and exists in addition to those arising in manufacturing operations.

Linkages in which this error has been minimized for some of the more common functions encountered in engineering are presented in Table 1. Other practical linkage forms for which the error has not been minimized are given in Table 2.

Basic Concepts: Consider the basic mechanism as shown in Fig. 1. Within the prescribed range, $x_s \leqq x \leqq x_f$, the ideal function,

$$y = f(x)$$

is generated by the analogous shaft rotations ϕ and ψ, where symbols are defined in Nomenclature and Fig. 1.

Further,

$$y_s = f(x_s)$$

$$y_f = f(x_f)$$

and x_s, y_s, x_f, and y_f correspond to angles ϕ_s, ψ_s, ϕ_f, and ψ_f, respectively, according to the relationships:

$$\phi = \phi_s + r_\phi(x - x_s)$$

$$\psi = \psi_s + r_\psi(y - y_s)$$

where $\phi = \phi_i$ and $\psi = \psi_i$ at $x = x_i$.

Design Possibilities: Step-by-step development of a linkage design from the tables is detailed in Fig. 2.

Application possibilities for various linkage forms are illustrated in Fig. 3.

Generally, functions suitable for generation by a four-bar mechanism (1) have ranges less than 120 deg; (2) are not symmetric about the midpoint [if midpoint is $x = 0$, avoid situations where $f(x) = \pm f(-x)$]; and (3) can be accurately generated if monotonic and if the slope does not change too much, and also where a special relationship is involved such as in the steering mechanism functions, Table 2. Further details are discussed in the literature.[9] With prescribed scale factors, five precision points can usually be obtained. The proportions and transmission ratios are not prescribed, however, and the scale factors should be chosen with care (Reference 4, pp. 110-111).

Purpose of the tables, which are designed to be self explanatory, is to illustrate the linkage types, functions, ranges, and accuracies possible and to reduce the design time which up to now has been a limiting factor in the use of these mechanisms. The computer program from which the tables were obtained is available on request from the author.

ACKNOWLEDGMENT

The author is much indebted to the Electronics Research Laboratory of Columbia University for the use of the I.B.M. 650 computer and to Mr. Jonathan Robbin and Mr. Tom Chinlund for their advice in programming and help in running the computer.

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230	10	10	1	1
440	10	10	—	—
600	10	10	—	—

*Non-inductive resistance loads.

Coils: Standard A.C. coils for 110, 208-220, 440, or 550 volts, 50-60 cycles. Standard D.C. coils for 115 or 230 volts. Other coils on special order.
Poles: 2 to 8, in all combinations of N.O. and N.C. contacts, convertible from N.O. to N.C. and vice versa.

†Dimensions:

A.C.	D.C.	Width	Height	Depth
4 pole	—	3¼"	5 1/16"	3 3/32"
8 pole	—	5⅛"	5 11/16"	3 3/32"
—	4 pole	3⅜"	5¾"	3 3/32"
—	8 pole	5⅛"	5¾"	3 3/32"

†Mounting centers for all models are identical.

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Discussion of sliding experiments using zinc, copper, titanium, and 1020 steel. Results are covered in terms of surface energy and hardness of the metals. Low ratio of surface energy to hardness indicates favorable friction properties of metals at high temperatures.

ASME paper 58-LUB-6, from ASLE-ASME Lubrication Conference, Los Angeles, October, 1958; 7 pp.

The Gas-Lubricated Sector Thrust Bearing

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An exact solution for a sector thrust bearing with side leakage and film variation in angular and radial direction taking into account effects of gas compressibility. Compressibility is introduced into the mathematical solution by assuming that density varies but kinematic viscosity remains constant. A numerical example which illustrates the method is included.

ASME paper 58-LUB-5, from ASLE-ASME Lubrication Conference, Los Angeles, October, 1958; 7 pp.

An Investigation of Dry-Adhesive Wear

R. P. Steijn, E. I. du Pont de Nemours and Co.

A discussion of sliding-motion experiments on various metals under unlubricated conditions. Oxide-film formation is studied by electrical contact-resistance measurements made in conjunction with wear tests, and effects on wear rate and basic wear formula are discussed. Discrepancies in wear rules are reported for the condition of brass sliding against brass where wear rate is affected by geometry of the apparent contact area.

ASME paper 58-LUB-8, from ASLE-ASME Lubrication Conference, Los Angeles, October, 1958; 10 pp.

Bearing and Seal Development

S. Gray, Fairchild Engine and Airplane Corp.

Results of a program which investigates small oil-lubricated accessory-size ball bearings at extremes of speed and temperature. Work covers bearing types, new high-temperature lubricants, and effects of high-speed operation on wear and vibration. Development of a Freon-12 shaft seal designed for an aircraft-type refrigeration compressor and conditions for successful operation of bearings and seal are outlined. High-speed rotating shaft seals of various carbide materials are evaluated.

ASME paper 58-LUB-10, from ASLE-ASME Lubrication Conference, Los Angeles, October, 1958; 16 pp.

hydraulic

Ramjet Fuel Controls

F. A. Heinz Jr., Bendix Aviation Corp.

An explanation of the operation of a typical ramjet fuel control system and various aspects of controlling the flow of fuel to such an engine. Functions of the various components within the system are described, and instrumentation pertinent to the fuel system is included.

ARS paper 661-58, from ARS Fall Meeting, Detroit, Mich., September, 1958; 5 pp.

Hydraulic Components for Missiles and Space Vehicles

A. B. Billet, Vickers Inc.

A discussion of developments in new miniaturized hydraulic components for space-vehicle application. Components include pumps of the variable-displacement, fixed-displacement, and vane types. High-temperature actuators, package hydraulic systems, and reliability of these components are covered.

ARS paper 657-58, from ARS Fall Meeting, Detroit, Mich., September, 1958; 8 pp.

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W. H. Henley

Characteristics of the ramjet engine of interest to control engineers. An approach to the synthesis of a ramjet control system is outlined. Discussion is largely qualitative and intended primarily to provide a physical insight into basic considerations involved. Significance of engine parameters on operating conditions is considered and a resume made of control component design criteria including power availability, environmental conditions, and space limitations. Pneumatic-hydraulic and electronic controls are analyzed and compared, and reasons given for selection of pneumatic-hydraulic components.

ARS paper, from ARS Fall Meeting, Detroit, Mich., September, 1958; 20 pp.

lubrication

The Mechanism of Gear Lubrication

V. N. Borsoff, Shell Development Co.

A brief review of current research on fundamentals of gear lubrication. Scoring and wear of gears are evaluated as functions of operating variables, gear geometry, construction factors, and lubricants. Included are the results of experiments with extreme-pressure lubricants showing distribution and thickness of extreme-pressure films and rates of attrition. Gear materials include steel, cast iron, and bronze.

ASME paper 58-LUB-4, from ASLE-ASME Lubrication Conference, Los Angeles, October, 1958; 10 pp.

mechanical

Shrink-Fitted Assemblies

F. Orbeck, Det norske Veritas, Oslo

A study of shrink-fitted assemblies loaded in torsion with special reference to damping capacity. The explanation of damping is related to elastic deflection and conditions of mating surfaces of the assemblies. Included are characteristics of differential slip and stiffness.

Prepared for the Institution of Mechanical Engineers, Great Britain.

Design of Escape Capsules

G. M. Root, Northrup Aircraft Inc.

A summary and discussion of major factors and problems associated with emergency escape from high-speed aircraft and their influence on design. Factors influencing design are divided into survival and cost factors and each is discussed separately.

SAE paper 91D, SAE National Aeronautic Meeting, Los Angeles, September, 1958; 12 pp.

techniques

Calculation of Transients In Cross-Flow Heat Exchangers

G. M. Dusinberre, The Pennsylvania State University

A method for calculating transient temperatures in a cross-flow heat exchanger by numerical methods. Digital computer programming is considered, and a gas-turbine regenerator is used as an example. In particular, methods are developed which are useful when flow rates vary, as in the starting transients.

ASME paper No. 58-HT-5, from ASME-AIChE Joint Heat Transfer Conference, Chicago, August, 1958; 7 pp.

Solutions of Transient Heat-Conduction Problems

W. D. Murray, Burroughs Corp., and F. Landis, New York University

Development of two new numerical methods for solving problems of one-dimensional heat conduction involving melting or freezing. These new methods are applicable to digital and analog computation. Sample problems using these and more conventional techniques are solved. An evaluation of methods and recommendations on areas of application are also included.

ASME paper 58-HT-16, from ASME-AIChE Joint Heat Transfer Conference, Chicago, August, 1958; 35 pp.

Digital Computer Application To System Components Design

H. R. Tuck and R. Galin, General Motors Corp.

An approach to obtaining optimum design of heat exchangers and air-handling equipment by digital computer use. How trial and error approaches to blower design problems are eliminated by computer techniques is shown, and a step-by-step procedure for programming the problem of analyzing over 150 blower wheels is included. Advantages of computer methods include reduced design time and achievement of optimum design of system components.

General Motors Engineering Journal, *Vol. 5, No. 3, July-August-September, 1958; p. 17-21.*

Considerations of Latent Heat In Computer Calculations

G. M. Dusinberre, The Pennsylvania State University

A method, especially suitable for digital computers, for calculating transient temperatures in solids. The method is helpful for overcoming difficulties in calculation caused by such things as a phase change involving a latent heat for high instantaneous values of specific heat. Such changes occur typically in melting or freezing or at transition points in metals, notably steel. An advantage of the procedure is that only one algebraic and explicit formula is necessary.

ASME paper 58-HT-7, from ASME-AIChE Joint Heat Transfer Conference, Chicago, August, 1598; 3 pp.

System-Performance Prediction

R. E. Roberson, North American Aviation Inc.

A review of some past developments toward a sound basis for reliability as an evaluation factor in system performance. The method of zero failure probability is discussed and evaluated. This approach to performance predictions utilizes both the inherent accuracy of the system and other reliability concepts. Advantages, disadvantages, and modifications of the method of zero failure probability are analyzed. An alternate method is then described and an alternative approach to performance prediction is proposed.

ARS Paper 656-58, from ARS Fall Meeting, Detroit, Mich., September, 1958; 10 pp.

Steady-State Network Analysis For Solving Heat Flow Problems

A. D. Kraus, Sperry Gyroscope Co.

A description of four methods of steady-state circuit analysis that can be applied to solutions of heat-flow patterns. The methods permit evaluation of complicated thermal configurations but still preserve an accuracy not attainable with simplifying assumptions made in order to evolve more simple cases.

ASME paper 58-HT-14, from ASME-AIChE Joint Heat Transfer Conference, Chicago, August, 1958; 13 pp.

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Quick Coupling Assemblies

Catalog F-10-R on Kamlik quick coupling assemblies features a recommendation chart for chemical service. It illustrates couplings for up to 200 psi pressures, lists recommended operating conditions for units made of various metals, and tabulates general dimensions. 8 pages. OPW Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

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Lubricating Equipment

Oil cups, oiling systems, dispensers, valves, oil gages, and chain oilers are among the Oil-Rite lubricating equipment listed with appropriate specifications in Catalog 10. Fifteen loose-leaf supplements describe automatic lubrication of various machines, accessories, and special lubricating items. 32 pages. Oil-Rite Corp., 2318 Waldo Blvd., Manitowoc, Wis. K

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Tubular Products

Both seamless and welded stainless steel tubing, nickel and nickel alloy tubing, special metals and alloys, and fabricated parts and specialties are described as to general characteristics, sizes, and tolerances in Bulletin 12. Stainless tubing is made in mechanical, aircraft, capillary, and hypodermic grades. 12 pages. J. Bishop & Co., Malvern, Pa. E

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Vinyl Cladding Material

Masland Duran Clad, a semirigid vinyl that can be laminated to sheet metal or continuous coils, then formed into product components, is subject of available folder. Material gives metal products a durable textured plastic finish. Masland Duraleather Co., Amber & Willard Streets, Philadelphia 34, Pa. E

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Stainless Heat Exchangers

Features that assure maximum heat transfer are pointed up in Bulletin 301.6K1 on Type SSCF all-stainless steel heat exchangers for production and pilot plant applications. Specs are given on 19 models available in one, two, and four-pass designs. 4 pages. American Radiator & Standard Sanitary Corp., Ross Heat Exchanger Div., Buffalo 5, N. Y. N

Circle 556 on Page 19

Temperature Controls

Indicating and recording models of Partlow pneumatic temperature controls are briefly described in Form 1087. Units operate on 3 to 15 psi air pressure and have an adjustable throttling range of 3-20 per cent. 4 pages. Partlow Corp., New Hartford, N. Y. D

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Precision Fasteners

Thirtieth anniversary products bulletin outlines the broad range of precision fasteners available with special features. It shows cold-forged fasteners produced for the automotive, aircraft, appliance, farm equipment, engine, and other industries. 4 pages. Chandler Products Corp., 1493 Chardon Rd., Cleveland 17, Ohio. F

Circle 558 on Page 19

Beryllium-Copper Tubing

Data Memorandum No. 7 deals with mechanical and physical properties, applications, corrosion resistance, production limits, heat treatment, fabrication, and size tolerances of small-diameter beryllium-copper tubing. Common applications listed are springs, Bourdon tubes, bushings, bellows, and ball-bearing races. 6 pages. Superior Tube Co., Norristown, Pa. E

Circle 559 on Page 19

Extruded Teflon

Weights and nominal wall thickness, prices, dimensions, and other data pertinent to extruded Teflon rods, tubing, coaxial cable cores, and aircraft and industrial hose liners are tabulated in Bulletin 158. 6 pages. Surf Chemical Inc., Harrison, N. J. D

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Air Clamp Cylinders

Improved 1⅛ in. clamp type universal, clevis, or pivot mount air cylinder for tooling, jigs, and automation uses is described in Bulletin 458. It operates on 150 psi air, 400 psi hydraulic with large safety factor. Bulletin gives specifications and other details. 4 pages. Sheffer Corp., 326 W. Wyoming Ave., Cincinnati 15, Ohio. G

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AC Generators

Data Sheets HV 558 and MG-658 respectively describe high voltage ac generators and the typical frequency converting motor-generator set. Two bearing, 150 kw, 60-cycle generators and single and standard two bearing, 60 to 400 kw units are covered. Motor-generator set is rated 150 kva. 2 pages each. Kato Engineering Co., Mankato, Minn. J

Circle 562 on Page 19

Tubular Fabrications

Tube forms of special contours to meet mechanical and structural requirements for aircraft, missile fuel, and control parts are shown in bulletin. Intricate small-diameter tube forms of stainless steel for servo mechanisms are included. 4 pages. United Metal Fabricators, Inc., 3991 Jennings Rd., Cleveland 9, Ohio. F

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Heating Coils

Bulletin 890 contains complete coil selection information as well as detailed description of Herman Nelson heating coils. Standard steam, steam distributing, and hot water coils are covered, and 8 pages of temperature rise charts are given in the steam coil section. 30 pages. American Air Filter Co., 215 Central Ave., Louisville 8, Ky. G

Circle 564 on Page 19

Mechanical Seals

Illustrated bulletin is descriptive of a line of precision mechanical seals for all makes, models, and sizes of centrifugal pumps, as well as for practically all rotating shaft sealing problems. Design features are shown with sectional views. 4 pages. Borg-Warner Corp., Mechanical Seals Div., Box 2017, Terminal Annex, Los Angeles 54, Calif. L

Circle 565 on Page 19

Electronic Voltmeters

Short form Catalog 10-A deals with panel mounted, single and multiple range, direct and alternating current, half-relay rack style, militarized and commercial, and miniaturized electronic voltmeters. Instruments are usable for checking critical voltages, plug-in circuitry modules, and for control purposes with a contact-making element. 4 pages. Metronix, Inc., Chesterland, Ohio. G

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Ductile Iron

When to use ductile iron castings and how major engineering features are controlled in good foundry practice are treated in quick reference folder on ductile iron. Nodulite ductile iron is cast in weights from 1 oz to 1500 lb. 6 pages. Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio. G

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Today's product designer, control systems engineer, nuclear physicist, and graphic panel manufacturer have a common need—an instrument capable of measuring elapsed time to a hundredth of a second, with an accuracy better than 0.02 of 1%.

Wide field—wide requirements

But there the sameness ends—the nuclear physicist needs a hermetically sealed device for remote control; the product designer requires load switches and local pushbutton reset; the graphic panel man wants smart appearance. The lab technician wants a portable model. The military asks for the smallest unit consistent with reliable readings, while the sports event timekeeper must have a large dial.

How can you meet these diverse requirements? Well, here's the answer to that question—a product of Cramer's experience and knowledge of precision timing.

Accuracy for everybody

You select a small, powerful and inherently accurate drive motor, add a 110-tooth positive clutch and apply it on the high-speed shaft. Back it up with a potent relay. When the signal comes, the unit responds instantly, and we have *accuracy*.

All-electric operation for flexibility

Add heart cams on the mainshaft and a rugged solenoid to belt them home within 1/10 second after the reset switch is operated. Now we have *electrical reset*, either remote or local.

For *versatility*, provide for load switches with cams on fast or slow pointer shafts. Cut and set at the factory, cams will offer a variable number (and duration) of pulses per second or minute, or with load switches wired in series, the unit can be used as a highly precise time delay relay or interval timer.

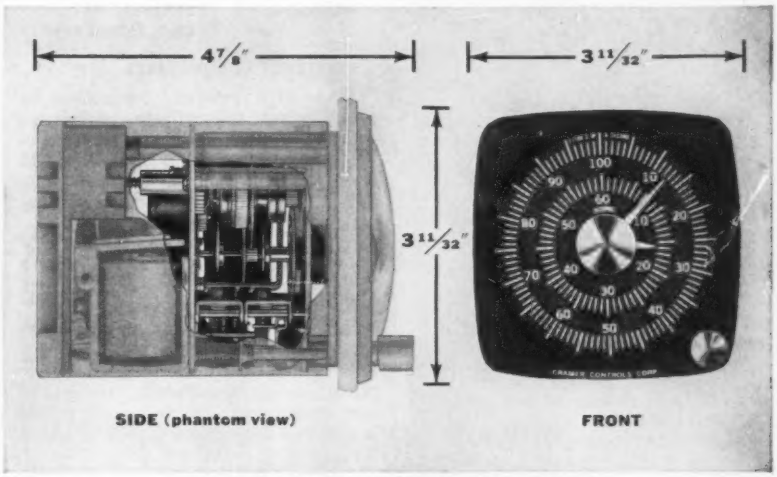
Commercial or Mil-Spec housings

Now let's enclose the mechanism. Commercial housing is dust-tight and has a 12-place terminal block. Also developed: a militarized model to withstand high vibration, shock and severe environments. A deep-drawn solder-sealed enclosure with 14-pin glass-beaded header, evacuated and hermetically sealed will do it.

Dials, pointers — Loewy styled

What's left? The business end of things — dial and pointers. Let's tackle this for readability, and at the same time, shoot for eye-appeal. This time we'll go to the *styling* experts — famous industrial designers, Raymond Loewy Associates. They come up with the last word in human-engineered dial-pointer combination for fast, exact readings. Frame it with a pleasing bezel that can be finished to match or harmonize with your panels.

Now it looks like the precise instrument that it is — the new Cramer Type 691 Time Totalizer. Bulletin PB 691 tells more about it. For detailed information and complete specifications, write Cramer Controls Corp., Box 6, Centerbrook, Connecticut.



TYPE 691 PRECISION ELECTRICAL STOP CLOCK

	Total Range	Outer Scale	Inner Scale
		Each Division	Each Division
TIME RANGES:	60 sec.	.01 sec.	1 sec.
	60 min.	.01 min.	1 min.
	60 min.	1 sec.	1 min.

RATINGS: Motors — all standard voltages at 50, 60 and 400 cps, and 28 volts DC (chronometrically governed); clutches and solenoids — all standard voltages at 50 and 60 cps, and 28 volts DC.

ACCURACY: Within .01 second for 60-second units, and within .005 minute for 60-minute units.

ELECTRICAL RESET: Actuated either by momentarily pressing pushbutton on timer bezel, or by closing a remote switch. Timer pointers return to zero within 1/10 second.

LOAD SWITCHES: One or two, optionally available, SPDT, rated 5 amperes at 115 and 230 volts AC (resistive), 2 amperes at 28 volts DC.

CAMS: Optional, to operate load switches. Precision-cut to exact time specifications, they can provide a series of electrical pulses during timing, or transfer switch contacts at any point or points within the time range of the unit.

EXTERNAL CONNECTIONS: All connections to motor, clutch, reset solenoid and load switches are brought out to numbered terminals.

MIL-Specs: Hermetically-sealed military units meet vibration, shock and environmental requirements of MIL-E-5272A.

TALK IT OVER WITH

CRAMER CONTROLS CORPORATION

Circle 464 on Page 19

RACINE SECO

Hydraulic Pumps

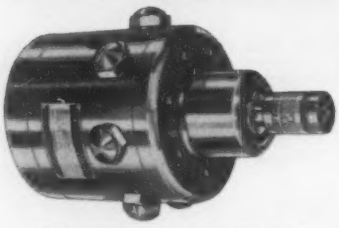
OFFER MAXIMUM PERFORMANCE AND ADAPTABILITY

LOW PRESSURE — HIGH VOLUME
Model R Vane Type Pump
40 gpm — up to 1000 psi.

features

VANE TYPE PUMPS

- ★ 5 to 70 gpm — up to 1000 psi
- ★ Variable volume for reduced horsepower consumption
- ★ Maintain pressure without costly waste of by-passing oil
- ★ Variety of governors available to suit your requirements



HIGH PRESSURE — LOW VOLUME
Model LA Radial Piston Pump
½ to 20 gpm — up to 10,000 psi.

RADIAL PISTON PUMPS

- ★ ½ to 20 gpm — up to 10,000 psi
- ★ ISO-FLO design for several isolated flows from *one* pump
- ★ Isolated flows at one pressure or several pressures
- ★ Ideal for accumulator circuits and parallel feed of cylinders

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2073 Albert Street RACINE, WISCONSIN

Circle 465 on Page 19

HELPFUL LITERATURE

Variable Speed Motor Drive

The Reeves Sanitary-type Vari-Speed Motodrive is designed to fill sanitary requirements of the food and allied industries. Bulletin M-588 describes design features and gives condensed drive specifications. 8 pages. Reeves Pulley Co., Columbus, Ind. J

Circle 568 on Page 19

V-Belt Drives

"How to Get Longer Life from V-Belt Drives" is title of illustrated manual which tells how to select and install V-belts, how to detect drive trouble, diagnose belt failures, and correct drive troubles. 12 pages. B. F. Goodrich Industrial Products Co., Akron, Ohio. F

Circle 569 on Page 19

Centrifugal Compressors

Single stage centrifugal compressors for petrochemical and refinery applications reviewed in bulletin 165 range in capacities from 1200 to 80,000 cfm. Series OM for low pressure air service, and Series OPB for gas and high pressure air uses are presented. 4 pages. Clark Bros. Co., Olean, N. Y. N

Circle 570 on Page 19

Localized Plating

How the Dalic process of high speed brush plating can be used to advantage in touch-up, bearing fitting, soldering, printed circuit manufacture, resizing of components, and electrical maintenance is explained in booklet entitled, "Practical Brush Plating with the Dalic Process." 12 pages. Marlane Development Co., 153 E. 26th St., New York 10, N. Y. D

Circle 571 on Page 19

Teflon Hose Assemblies

Application and design information on flexible hose assemblies of Teflon, complete with fittings, is presented in Bulletin TC-101. Such uses as fluid handling, hydraulic power service, and electrical conduit are explained. 16 pages. American Brass Co., American Metal Hose Div., Waterbury 20, Conn. C

Circle 572 on Page 19

Friction & Fluid Drives

Small, medium, and large mechanical clutches; wet and air-actuated clutches; power take-offs; reduction gears; fluid couplings; single and three stage torque converters; and marine gears are covered with condensed specifications and design data in Bulletin 314 on Twin Disc friction and fluid drives. 20 pages. Twin Disc Clutch Co., Racine, Wis. K

Circle 573 on Page 19

Control Valves

Design features, including single-seated valve body, 600-psi ASA rating in all sizes, and separable or integral flanges, are discussed and illustrated in Bulletin LB-3 on Series LB control valves. Operation of the Model J valve positioner is shown. Optional accessories are illustrated. 12 pages. Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa. E

Circle 574 on Page 19

NO PREHEAT NO POSTHEAT

on

HIGH TENSILE STEEL

when you weld with

AIRCO 394

- ✻ Airco 394 all-position electrodes overcome underbead cracking in welding of most hardenable steels — without preheat.
- ✻ Make possible high quality hardenable steel welds without postheat.
- ✻ Weld steels of 30% or more carbon.
- ✻ Recommended wherever steels contain both alloying elements and high carbon.

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Airco 394 electrodes produce a manganese molybdenum deposit of low hydrogen content. Weld metal is of high strength. Arc action is steady, beads are smooth, slag removal is easy.

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Circle 466 on Page 19

Cartridge Filters

Aid in selecting the proper filter and cartridge for various fluid and gas services is offered in Catalog 53-101. Included are a Micro-Klean selector chart, cartridge life curve, flow rate table, and other performance data. 12 pages. Cuno Engineering Corp., S. Vine Street, Meriden, Conn. B

Circle 575 on Page 19

Electronic Tube Holders

Top-holding tube and component retainers for electrical and electronic equipment are described in Catalog 2-TT. Types and sizes are available for practically every component holding need. 12 pages. Birtcher Corp., 4371 Valley Blvd., Los Angeles 32, Calif. L

Circle 576 on Page 19

Hydraulic Components

Condensed specifications and features of hydraulic components for mobile equipment are contained in Bulletin 1502. Folder reviews directional control valves, accumulators, cylinders, hose assemblies, and tube fittings. 4 pages. Parker-Hannifin Corp., Parker Hydraulics Div., 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 577 on Page 19

Air Control Valves

Details of the new line of two-way air control valves for use with air-operated hydraulic lifts, hoists, and other industrial equipment are contained in Bulletin F-44. This ½-in. control sells for $13.95. 2 pages. OPW Corp., Jordan Industrial Sales Div., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 578 on Page 19

Steel Sheets & Strip

Offered as a buyer's guide to all types of steel sheets and strip, Bulletin 20-1 lists types available for prompt shipment in the form of coils, stock sizes, and cut-to-order sizes. Characteristics of each type are stated. Also covered is prepainted steel. 8 pages. Joseph T. Ryerson & Son, Inc., Box 8000-A, Chicago 80, Ill. J

Circle 579 on Page 19

Coatings

Clear and colored roller, spray, and screening coatings for use on metal, plastics, glass, and wood are described in plastic-bound brochure. Data is given on standard colors, including metallics, bronzeless gold, and special effects. Application information is given. 38 pages. Bee Chemical Co., 12933 S. Stony Island Ave., Chicago 33, Ill. J

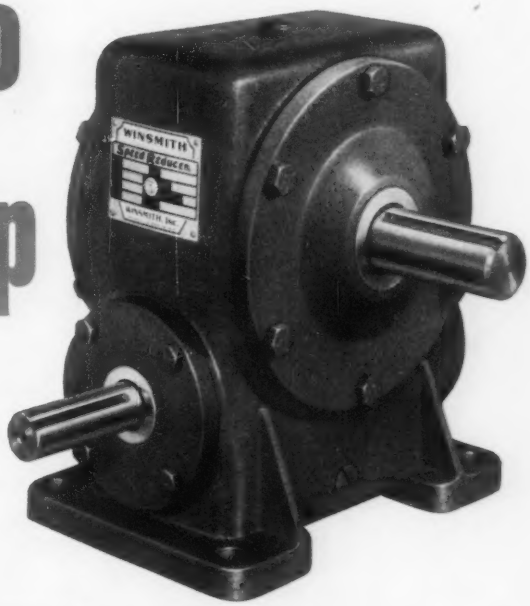
Circle 580 on Page 19

Electrical Connectors

Battery and power connectors for high current capacity and battery disconnect applications are covered in detail in revised Catalog GB-7-2958. Connection of auxiliary power equipment to aircraft electrical systems is one of applications. Specifications are given. 20 pages. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif. L

Circle 581 on Page 19

for applications up to 34 hp



Winsmith worm gear speed reducers

Rugged, heavy-duty units capable of handling up to 34 horsepower are immediately available from Winsmith's stock line of worm gear speed reducers. To meet your exact requirements, Winsmith offers you the widest range of standard models, capacities and drive arrangements from a single source of supply. For compact design, trouble-free performance and long-run efficiency, economy and durability — standardize on Winsmith.

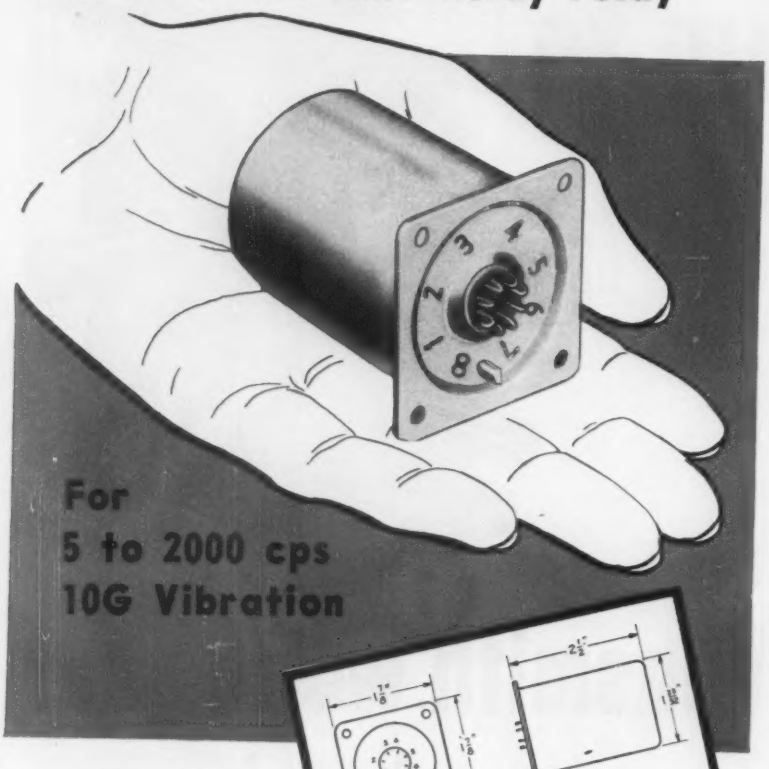
WINSMITH SPEED REDUCERS

WRITE TODAY for Catalog No. 155 for information on selection, operation and maintenance of the hundreds of types and sizes of Winsmith Speed Reducers.

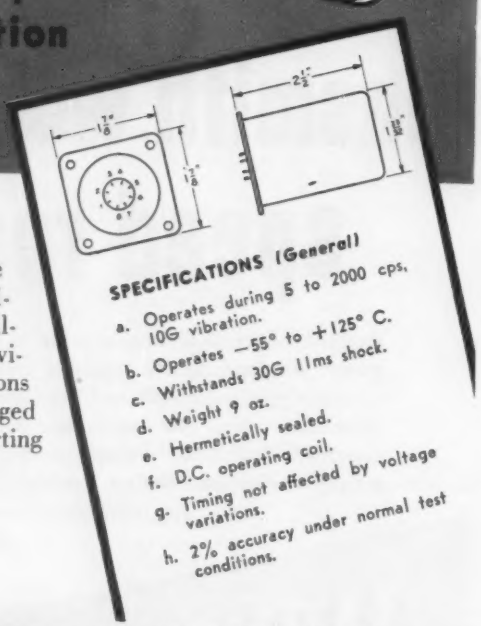
WINSMITH, INC. 16 Elton Street, Springville, (Erie County), N. Y.

Circle 467 on Page 19

NEW! TYPE AX1
EAGLE D.C. time delay relay



Uses new type escapement principle. Utmost reliability under severe environmental conditions is insured by its rugged design and self-starting characteristics.


SPECIFICATIONS (General)
a. Operates during 5 to 2000 cps, 10G vibration.
b. Operates −55° to +125° C.
c. Withstands 30G 11ms shock.
d. Weight 9 oz.
e. Hermetically sealed.
f. D.C. operating coil.
g. Timing not affected by voltage variations.
h. 2% accuracy under normal test conditions.

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ADDRESS

CITY ZONE STATE

Circle 468 on Page 19

HELPFUL LITERATURE

High Impact Plastics

Properties of some Fiberite materials are tabulated and various applications of this impact plastic molding compound are pictured in folder. 4 pages. Fiberite Corp., 512-528 W. Fourth St., Winona, Minn. J

Circle 582 on Page 19

Cold Finished Bars

Cold finished steel bars are listed on an 11 x 17-in. wall chart which lists 241 AISI grades and their chemical analysis. Machinability ratings are given and a table of weights gives pounds per foot for each shape and diameter. 5 pages. La Salle Steel Co., Box 6800-A, Chicago 80, Ill. J

Circle 583 on Page 19

Lubricants

Effect of lubricants on the wear-in of new machinery is discussed in Lubrication Newsletter No. 5. An engineering study of the surface geometry of mating surfaces is included. Actual test records are pictured and analyzed. 8 pages. Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn. B

Circle 584 on Page 19

Hydraulic Cylinders

Technical specifications, design features, mounting dimensions, dimensional drawings, and ordering information for Powrdraulic cylinders are found in illustrated Catalog 900. The 1½ to 8-in. bore sizes listed are for 2000 psi or 3000 psi nonshock service. 8 pages. Hanna Engineering Works, 1765 N. Elston Ave., Chicago 22, Ill. I

Circle 585 on Page 19

Servo Motors

Design features of totally enclosed, ball bearing, and full slot, spiral, direct current servo motors are featured in Bulletin GEA-6831. They are suited for fast response to control signals in applications requiring frequent starts, stops, reversals, and widely fluctuating loads. 2 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 586 on Page 19

Rating Electron Tubes

Application Note AN-174 entitled "Design-Maximum System for Rating Electron Tubes" reviews the significant differences between the three rating systems now in use: Absolute-maximum, design-center, and design-maximum. The latter is discussed in detail. 32 pages. Radio Corp. of America, Electron Tube Div., Harrison, N. J. D

Circle 587 on Page 19

Cylinder Rod Wiper

Two-bladed Houghto Seal-Guard hydraulic cylinder rod wiper which clears dust, grit, weld splatterings, mud, and ice from a reciprocating rod is subject of illustrated bulletin. Stock sizes are listed and installation data are included. 4 pages. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa. C

Circle 588 on Page 19

Selenium Rectifiers

Selenium Slims, described in illustrated bulletin, are high voltage, cartridge type, selenium rectifiers with direct current ratings of up to 10 milliamp and 12,365 v. Glass or phenolic tube types are available. 8 pages. Syntron Co., 260 Lexington Ave., Homer City, Pa. F

Circle 589 on Page 19

Timing Devices

Bulletin 700 is descriptive of running time meters and synchronous motor driven reset time totalizers. Instruments are available for use on 115, 220, or 440-v 25, 50, or 60-cycle ac. 2 pages. Industrial Timer Corp., 1407 McCarter Highway, Newark 4, N. J. D

Circle 590 on Page 19

Insulating Laminates

Grade G-5, a laminated plastic having high tensile and flexural strengths plus high arc and flame resistance, is described in Technical Data Bulletin 4.5.1. Applications in electric equipment are discussed. 4 pages. Taylor Fibre Co., Norristown, Pa. E

Circle 591 on Page 19

Electrical Connectors

Specifications, dimensions, and general information on the new Series G miniature electrical connectors are given in Bulletin G. They are available with 2, 3, and 4 contact arrangements. 2 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 592 on Page 19

Temperature Regulators

Extensive line of temperature regulators, safety controls and mixers, pressure regulators, vacuum valve, liquid level control, packless valves, and bulbs is briefly discussed and illustrated in Condensed Catalog D. 12 pages. Robertshaw-Fulton Controls Co., Fulton Sylphon Div., Knoxville 4, Tenn. A

Circle 593 on Page 19

Magnetic Amplifiers

Text and diagrams serve to explain the principles of magnetic amplifiers in Bulletin 1105-1. Performance curves illustrate operating characteristics, and schematics show how amplifier is incorporated into theater dimmers, autopilots, servo systems, speed regulators and boiler control systems. 36 pages. Available on letterhead request from Vickers Inc., Electric Products Div., 1815 Locust St., St. Louis 3, Mo. I

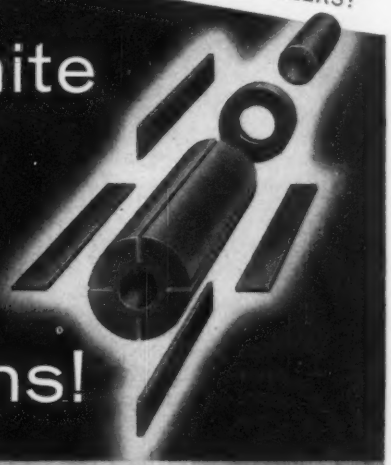
Dynamometers

"Dillon Dynamometers at Work in the World" is title of this stiff-covered brochure which pictures the use of traction type dynamometers for measurement of tensile, compression, or torque forces. All views are 8 x 10 in. and each includes pertinent engineering data and related facts. The application book will be available for a limited time for 50 cents when requested on company letterhead. 86 pages. W. C. Dillon & Co., Box 3008, 14620 Keswick St., Van Nuys, Calif. L

DESIGNERS AND ENGINEERS!

Self-Lubricating

Morganite solves today's critical design problems!



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Bearings, Seals, Piston Rings, Valves, Slides, Contacts, etc.

Insure trouble-free operation in continuous service in high temperatures and pressures, oil, corrosive acids, gases, grease and grime. Morganite components "step-up" efficiency, reduce failures and machine down-time. Install application-tested MORGANITE components for better performance on aircraft and industrial fuel pumps, meters, food and processing equipment, jet engine pumps, radar equipment, conveyors, compressors, sealed mechanisms and wherever lubrication is a problem. Engineering bulletins on typical applications available on request.

CALL OR WRITE now, for complete information or recommendations on your specific applications. Morganite engineers will gladly assist in working out your problems.

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Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

Circle 469 on Page 19

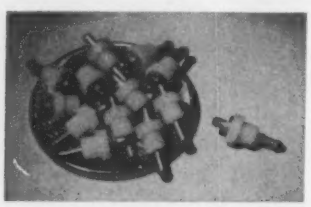
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Teflon Terminals

subminiature units are only 0.306 in. high

Press-Fit type FT-SM-125 subminiature Teflon terminals have a truncated end for one of the two lugs,



acting as a stop to prevent wrapped wire leads from slipping off until they can be soldered. Terminals have over-all height of only 0.306 in., fit into an 0.081-in. diam hole, and can be accommodated in any chassis up to 0.035 in. thick. They are available in code colors as well as white. **Sealectro Corp.**, Mamaroneck, N. Y. D

Circle 594 on Page 19

Solenoid Valve

three-way unit has nylon body

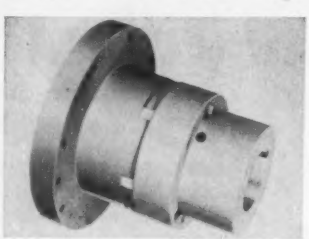
SV-54 three-way nylon-body solenoid valve is available for general-purpose and OEM installations where long life is essential. Nylon seat and port threads with dry seal do not loosen under severe vibration. Valve is available in normally open, normally closed and directional-control configurations. Shock-resistant and pressureproof, it is available in all normal ac and dc voltages. **Valcor Engineering Corp.**, 365 Carnegie Ave., Kenilworth, N. J. D

Circle 595 on Page 19

Flange-Type Coupling

can be bolted directly to flywheel

Model GHF flange-type coupling is available in sizes from 35 to 700 hp at 1800 rpm. It incorporates a flange for use on gasoline motors and other drives where coupling



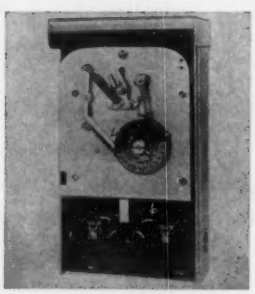
must be bolted directly to flywheel. Unit is also furnished with tapered bore to accommodate QD bushings. **Gerbing Mfg. Corp.**, Northbrook, Ill. J

Circle 596 on Page 19

Heavy-Duty Time Switch

controls substantial loads even under severe conditions

Series 2100 heavy-duty time switch controls substantial loads even under severe operating conditions. Switch rating is 55 amp at 120/240 v ac. Plunger-action, copper-to-copper contacts are mounted integrally with pressure-type copper wiring terminals. Switches are equipped with synchronous, self-starting motors with motor-current consumption of 3 w. Motors maintain synchronous speed at temperatures from



−20 to 150 F. Standard motor is used with 110/125-v, 60-cycle current with neutral tap for three-wire, 240-v circuits. **Paragon Electric Co.**, Two Rivers, Wis. K

Circle 597 on Page 19

In-Line Mechanisms

consist of rotating components on common or adjacent shaft

New electromechanical subassemblies known as in-line mechanisms consist of motors, reduction gears, clutches, potentiometers, switches, and other rotating components combined on common or adjacent shafts. They provide a logical grouping of design elements with reduced size and increased accuracy. Advantages include elimination of complex gearing and backlash, and provision of greater latitude in selection of transducers. Typical units include a synchro control transmitter and precision potentiometer mounted on a common shaft, an analog and digital readout for altitude measuring equipment, and a function programmer consisting of a two-phase servo motor, 1000:1 gear train, three pre-

Quietest Direct Drive Blower Motor

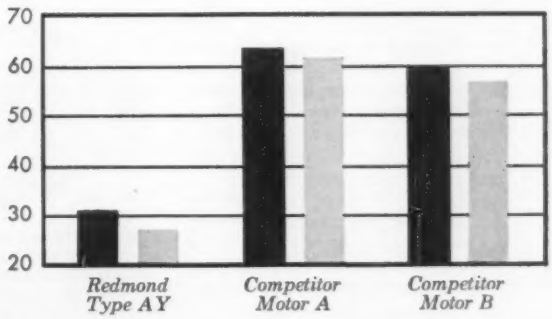
Place a mechanic's stethoscope on the end cap and you can easily hear the difference between the newly-designed Redmond Type AY and motors of conventional design. Try it on a Redmond 1/6 hp—the noise level is about that of a 1/35 hp motor of conventional design.

New Redmond Design Reduces Blower Vibration to One-Fifth that of units using Conventional Shaded-Pole Motors

Apply vibration tests and you will be quick to agree that here is the quietest direct-drive blower motor available. The AY Tri-Flux motor is designed and manufactured in every way to give years of trouble-free service and whisper-quiet operation. The positive oil system provides force-feed lubrication. Recirculating the oil assures maximum bearing life.

The graph shows vibration test results on the new Redmond design and two competitive motors. These tests were made with the best vibration testing equipment available. The solid black bar shows vibration on the motor end cap; the gray bar shows vibration on the blower housing. The graph is decibel readings on 120 cycles, since the 120 cycle frequency is the one that is the basic source of nearly all noise problems. Reduction of vibration is a logarithmic function—the reduction of vibration in the Redmond motor to 33 decibels reduces noise to only 1/5th that of conventional motors.

The new AY is ideal for a wide variety of applications requiring a whisper-quiet, economical, high-quality motor. Contact us at Owosso, Michigan, and we will have the Redmond sales engineer in your district call you at once.



The Standard of Dependability

Redmond COMPANY, INC.

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REDMOND

Here's how they cut equipment
operating costs with 2000 psi
DENISON hydraulic power
FOR LOW-COST
OPERATING POWER
Caterpillar's rugged No. 9 Ripper—proven tool for the famous D9 Tractor—counts on a Denison 2000 psi balanced-vane hydraulic pump.

Why CATERPILLAR picks DENISON to power the No. 9 Ripper

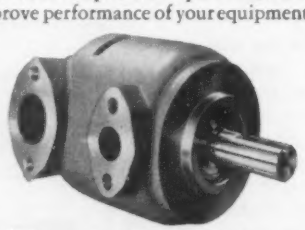
WHY? Because dependable 2000 psi Denison hydraulic power helps Caterpillar build *lower operating cost* and continuous, troublefree performance into its rugged earth-moving units.

Case in point: Here's Caterpillar's No. 9 Ripper—another of many construction units to be factory-equipped with Denison hydraulic equipment. The Ripper's hardworking teeth are powered by a single Denison vane-type pump which provides plenty of reserve "go" for toughest workloads.

Plus benefits: All-weather pump starting without pump damage . . . speedy field servicing . . . less weight . . . less cost-per-horsepower—with a Denison pump as the heart of a hydraulic system.

Caterpillar picks Denison hydraulic equipment for reliability . . . quality . . . proven field performance. It pays off in helping keep Cat® units operating continuously . . . profitably month after month.

Ask your Denison Hydraulic Specialist about how Denison hydraulic power . . . up to 5000 psi . . . can improve performance of your equipment.



2000 PSI HYDRAULIC POWER... *for operating Caterpillar's rugged No. 9 Ripper is delivered by a single Denison "T" series vane pump. Payoff: Jobs get done with trouble-free power to spare for toughest workloads.*

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DENISON HydrOILics

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

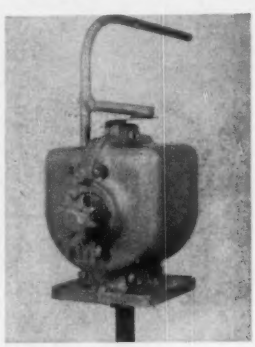
cision potentiometers, and a single-pole four-throw printed-circuit switch. **Spectrol Electronics Corp.**, 1704 S. Del Mar Ave., San Gabriel, Calif. M

Circle 598 on Page 19

Automatic Transmission

for small motorized vehicles

New automatic transmission for small motorized vehicles has maximum capacity of 4 hp at 2400 rpm and has life expectancy of 2600 hr. It can be used on vertical-shaft engines. Weighing only 13 lb, unit has one forward, one reverse, and neutral speed. Transmission is permanently lubricated. **Cizek Mfg. & Distributing Co.**, Clutier, Iowa. I

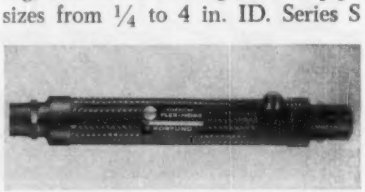


Circle 599 on Page 19

Flexible Metal Connectors

general-purpose units have high burst strength

General-purpose flexible metal connectors, designated Series B and S Flex-Hose, have new braid design which provides especially high burst strengths. Flex-Hose is corrugated, seamless tubing, protected and reinforced by outer braiding. Maximum steady working pressures at 70 F vary with size up to 1700 psi. Operating temperatures can be as high as 750 F, depending upon material used. Series B hose has bronze tubing, single bronze braiding, and brazed fittings, for 12 pipe sizes from ¼ to 4 in. ID. Series S



Circle 471 on Page 19

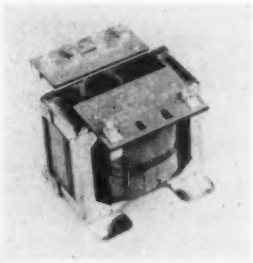
has steel tubing, braid woven of braided steel wire, and welded fittings, for seven pipe sizes from 5 to 16 in. ID. **Korfund Co. Inc.**, 48-190 32nd Place, Long Island City 1, N. Y. D

Circle 600 on Page 19

Core-and-Coil Transformers

are 15 per cent smaller and lighter than previous units

Two new lines of low-cost core-and-coil transformers are 15 per cent smaller and lighter in weight than previous designs. They have all-



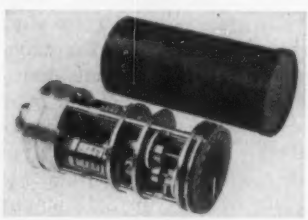
welded, four-poster core-clamping frame provided with slotted feet for machine-tool and panel applications. Transformers are available with terminal board, circuit breaker and fuse block accessories, or with leads out. Units are used to step down voltage of 240, 480, or 600-v distribution circuits used to supply small individual loads for control circuits, hand tools, motors, utility outlets, and work lights, and 6 to 32-v relays, lights, and other similar signal devices. Voltage is stepped down at the load, eliminating need for long secondary distribution circuits. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 601 on Page 19

Subminiature Servomechanism

is available in kit or assembled form

Model 20-200 servomechanism is available assembled or in kit form for use as a complete hermetically sealed, integrally lighted airborne



indicator, analog computer element, or control device. Large number of readout and component arrangements can be obtained to suit individual airborne military, industrial, or laboratory applications. Internal components can be arranged rapidly and easily in a variety of gear ratios, input-output components, and readouts. Seven shafts operating in ball bearing are available for gearing, and as many as three servo loops can be accommodated in a single unit. Up to six rotating components, size 8 (or two size 8 and two size 10) can be installed. Length varies according to application. **Servo Development Corp.**, 567 Main St., Westbury, N. Y. D

Circle 602 on Page 19

Epoxy Adhesive

is applied without sagging or running

One-part epoxy adhesive, designated Isobond 321, is a high-strength adhesive which is applied to any surface, including vertical, without sagging or running. Electrical insulation properties are excellent. Adhesion is very good to metals, ceramics, glass, cement, and all other temperature-stable materials. Operating temperature range is −55 to 200 C. **Isochem Resins Corp.**, 221 Oak St., Providence 9, R. I. B

Circle 603 on Page 19

Capillary Tubing

is up to 3000 ft long

Capillary tubing (3/16 in. OD or less) is now furnished in lengths up to 3000 ft. Longer tubing lengths provide greater uniformity than is possible when drawing same size of tubing at different times under different conditions and with different dies and mandrels. One continuous length of tubing can be used from sensing to indicating element, recording or controlling section of instruments, even though sensing element is distantly located. Standard capillary tubing is made from AISI Types 304, 316, 321, 347, and 446 stainless steels, C-1008 carbon steel, nickel, Monel, and Inconel. Tubing is furnished in random, multiple, and cut straight lengths up to 39 ft. Coils are fur-

How you save time and money with

DENISON

Super Market

hydraulic service...

1. BRING US YOUR PROBLEM – *Whatever* hydraulic problem has you stumped. A trained Denison Hydraulic Specialist is ready to help you solve it.

2. WE'LL DEVELOP YOUR CIRCUIT – The most efficient hydraulic circuit to handle your specific needs. We can do this while you wait.

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American Brake Shoe Co.
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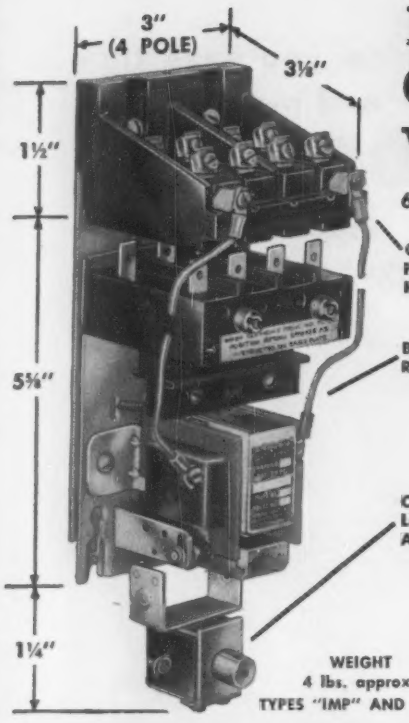
Circle 472 on Page 19



HEAVY DUTY RELAYS GREATEST Control Versatility Ever Offered

600 VOLTS AC • 10 and 15 AMPS • 2, 3, 4, 6 or 8 POLES

- **RUGGED and RELIABLE . . .** with exceptional electrical and mechanical life. Simple construction for easy maintenance.
- **OPTIONAL PLUG-IN RECEPTACLE . . .** allows fast replacement of relay *without* disturbing wiring. Minimizes down-time on high-output machines.
- **FAST, EASY COIL REMOVAL . . .** just remove 2 screws, swing coil to front and lift out entire assembly.
- **SIMPLE CONTACT CONVERSION . . .** from normally-open to normally-closed. No tools needed.
- **MOST VERSATILE LATCHING ATTACHMENT . . .** exclusive with A-H. Only attachment that converts in the field from "latch-in" to "latch-out" or "latch in-and-out."
- **AVAILABLE . . .** with AC or DC holding coils.

For free copy of the 8-page Heavy Duty Relay Catalog Section, write to The Arrow-Hart & Hegeman Electric Co., Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

ARROW – HART OF HARTFORD

Motor Controls • Wiring Devices • Appliance Switches • Enclosed Switches

Circle 473 on Page 19

ARROW AH HART

nished up to 3000 ft long in diameters of 18, 24, 30, or 36 in. **Superior Tube Co.**, 1578 Germantown Ave., Norristown, Pa. E

Circle 604 on Page 19

Pressure Control

is dual-switch unit for air, gas, liquids

Type J99A dual-switch pressure control is a wide-range, explosion-proof unit suitable for air, gas, or liquid pressures in hazardous locations where explosive gases or vapors are present. Two completely separate switches permit independent switch actions, control of two independent circuits, and flexibility of switching arrangement. Pressure settings are made by removing cover and setting hexhead adjustment screws. Switches can be set together to simulate double-pole circuitry or set apart to obtain independent operation. Control has cast-iron base and aluminum cover, permitting use in Class 1, groups

C and D; Class 2, groups E, F, and G; and Class 3 as defined by National Electrical Code. **United Electric Controls Co.**, 79 School St., Watertown, Mass. B

Circle 605 on Page 19

DC Control Motor

is permanent-magnet, 1/6-hp unit

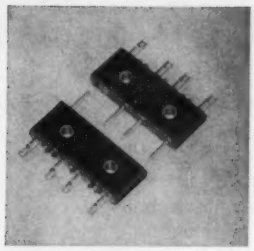
Model PC industrial dc control motor withstands severe service in adverse environmental conditions as encountered in processing, chemical and petroleum industries, and industrial automation applications. A permanent-magnet, 1/6-hp unit, it is designed as a building block for incorporation in control equipment, and is available with an integral tachometer-generator giving a 0 to 5-ma output signal linearly proportional to its speed. Speed is 0 to 4000 rpm, and torque is 40 oz-in. **Rotron Controls Corp.**, Woodstock, N. Y. D

Circle 606 on Page 19

Miniature Connectors

space-saving units are for side mounting

Series G miniature connectors are small, rectangular units designed for side mounting. Reverse pin and socket construction is adaptable to various pin arrangements that accommodate different circuit requirements. Over-all width varies from less than ½ to approximately ⅞ in., and thickness varies from ⅛ to slightly over ¼ in. Side mounting



also permits stacking of several units for compact assembly. Two, three, and four-contact units are available. **Electronic Sales Div., DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 607 on Page 19

Teflon Tape

for temperatures from −350 to 500 F

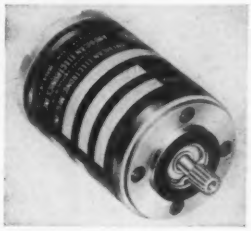
New Teflon tape, designated Fluorolin 600, has pressure-sensitive silicone adhesive and superior bondability and stability under extreme conditions. Layers of submicron-sized particles of Teflon are fused together to build up film thicknesses from 0.00025 to 0.005 in., providing a film free from pinholes and blemishes, and with excellent mechanical, chemical, and electrical properties. Film has many applications in the aircraft, electrical, and electronic industries. **Joclin Mfg. Co.**, Wallingford, Conn. B

Circle 608 on Page 19

Stepper Motor

has stepping rates of 90 pulses per sec

Model PM112A3 Size 11 stepper motor is a permanent-magnet rotor bidirectional unit for precision rotary motion without reciprocating



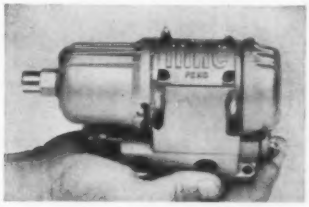
parts. Low rotor inertia plus low inherent power requirements provide stepping rates of 90 pulses per sec in random pulse direction. Motor is available with internal logic circuitry, either mechanical or solid state, for adaptation to existing systems and circuitry. Maximum weight is 4.7 oz. Unit operates in ambient temperatures from −55 to 100 C. **Instrument Div., American Electronics Inc.**, 655 W. Washington Blvd., Los Angeles 15, Calif. L

Circle 609 on Page 19

Four-Way Valve

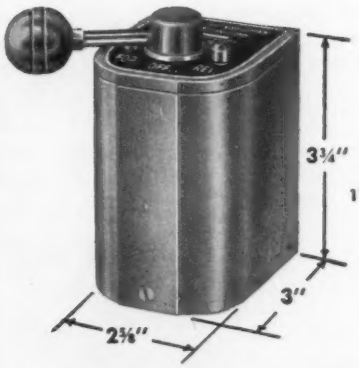
is light, compact, low-cost unit

Dual-Seal, compact, lightweight, four-way valve is available in ¼, ⅜, and ½-in. port sizes. It has

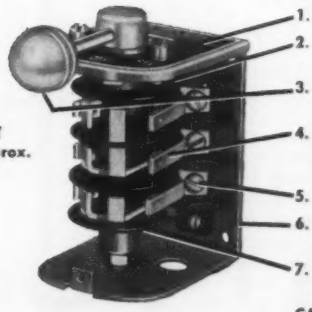


MOTOR CONTROLS

Reliable – Low-Cost – Durable
The NEW Type "DR" Reversing Drum Switch



WEIGHT
1½ lbs. approx.



1. Easy-To-Read Name Plate.
2. Easy Conversion from Maintained to Momentary Contact.
3. Self-Centering Handle with Positive Spring Action.
4. Heavy, Silver Plated Contacts for Long Electrical Life. Fully Visible, Easily Replaceable.
5. Easy-To-Wire Terminals.
6. Simple, Rugged Construction for Long Mechanical Life.
7. Insulation Barriers Between Contacts Prevent Flashovers.

CATALOG NO. DR-001: Size 00, has 3 poles arranged to break 2 lines to motor. Rated 1 hp maximum at 115 volts ac, single phase . . . or 220 volts ac, polyphase.

CATALOG NO. DR-02: Size 0, has contacts arranged to break 3 lines to motor. Rated 1 hp maximum at 115 volts ac, single phase to 2 hp maximum at 440-550 volts ac, polyphase.

For complete information on this new Type "DR" Reversing Drum Switch, write to The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

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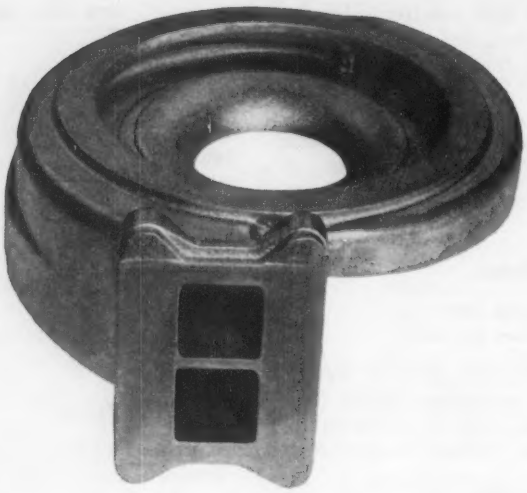
Circle 474 on Page 19



THERMAL SHOCK

A CASE IN POINT—This 20 pound Ni-Resist casting made for the Schwitzer Corporation by Hamilton Foundry is the turbine casing of a diesel engine turbocharger. Exhaust gases which turn the impeller at speeds up to 90,000 rpm subject the housing to rapid cyclic temperature changes up to 1500° F. Any free scale formed at these temperatures could erode and eventually destroy the impeller blades. Ni-Resist was chosen for this part because it produces practically no free scale, it resists growth and oxidation at high temperatures, and it resists cracking under thermal shock.

Ni-Resist iron combines three particular product engineering and design advantages. It resists oxidation: as low as .002 inches per year oxide penetration at 1400° F. Scale formed adheres to the base metal and reduces further oxidation to a minimum. It has high temperature strength: up to 12,000 psi at 1500° F. And it's the toughest of all flake graphite irons: Charpy impact strengths (unnotched) up to 150 ft.-lbs. Hamilton Foundry casts all types of Ni-Resist including Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY

The Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio • TW 5-7491

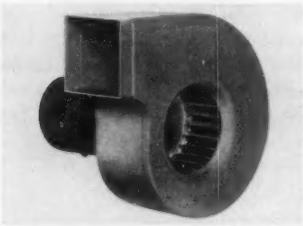
only three moving parts, reducing maintenance problems. Solenoid and cover can be detached easily without tools, and valve is inoperative with cover removed. Standardized, interchangeable manifold bases permit grouping of two to ten valves. When combined, bases form a single inlet, single exhaust, and single conduit channel. **Mechanical Air Controls Inc.**, 10030 Capital, Oak Park, Detroit 37, Mich. H

Circle 610 on Page 19

Centrifugal Blowers

cool electronic equipment with 20 to 2000-cfm flow

Low pressure centrifugal blowers in diameters from 2 to 9 in. cool electronic equipment in aircraft, missiles, radio, and computer service. Range of air delivery is from 20 to 2000 cfm, depending upon impeller size and motor speed. Input power is provided by either ac, dc, or 400-cycle aircraft motors. Total weight of unit is less than 2 lb. **Torrington Mfg. Co.**, Torrington, Conn. B

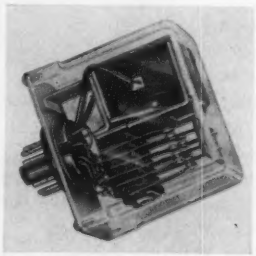


Circle 611 on Page 19

Industrial Relays

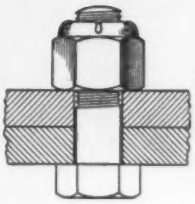
small units require low operating power

Frame 219 relays are compact industrial control units having small size and low operating power. They are mechanically protected by plastic covers and have plug-in construction for easy servicing. Accepted standards of insulation include spacings of $\frac{1}{8}$ in. through air, $\frac{1}{4}$ in.

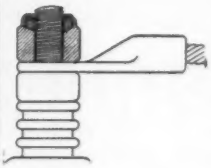


Ten fastening problems solved by ELASTIC STOP® nuts

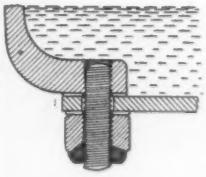
TIGHTENED AGAINST THE WORK



Vibration and impact proof bolted connections in standard applications.

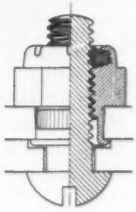


On all electrical terminals subjected to vibration in transit or operation, and for any electrical or electronic assembly where positive contact must be maintained.

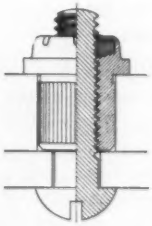


To seal bolt threads where leakage past stud threads must be prevented.

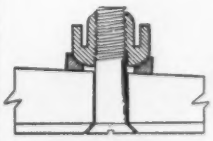
FOR MANY SPECIAL FUNCTIONS



Blind fastening applications where nut is "clinched" into sheet metal . . . becoming self-retaining as well as self-locking.

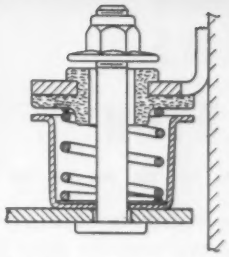


To eliminate drilling and tapping and provide steel thread strength for soft metals, an ESNA spline nut is pressed into a bored hole in casting.

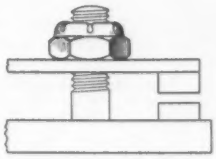


Simplified self-aligning self-locking fastener for bolting two non-parallel surfaces.

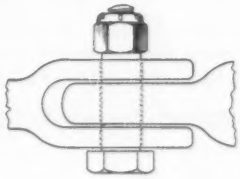
LOCKED ANYWHERE ON THE BOLT



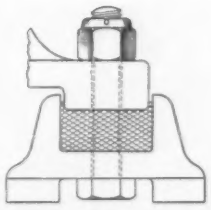
Spring-mounted connections or dynamic balancing, where nut must stay put yet be easily adjusted. (Flanged face eliminates need for extra washers.)



On make and break adjustment studs where accurate contact gaps must be maintained. Note "thin" height design for limited clearance.



For bolted connections requiring predetermined play.



For rubber-insulated and cushion mountings where the nut must not work up or down.

HOW THESE NUTS SOLVE SO MANY FASTENING PROBLEMS, ELIMINATING EXTRA PARTS AND OPERATIONS...

The red locking collar of an ELASTIC STOP® nut grips bolt threads with a perfect fit that will not loosen under severe vibration or stress reversals, and seals against liquid seepage. By bringing nut and bolt metal thread flanks into firm contact it eliminates wear producing axial play. The elastic locking action of the insert-type stop nut does not distort or gall bolt threads. It is reusable many times.

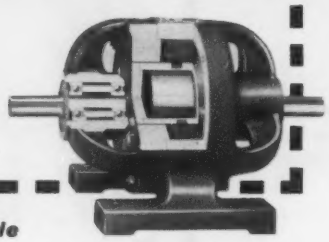
Send for the following free information: Elastic Stop nut bulletin; Rollpin® bulletin. Or enclose a drawing of your product for specific self-locking fastener recommendations. Write to Dept. N30-114.

Circle 476 on Page 19

ESNA®

ELASTIC STOP NUT CORPORATION OF AMERICA
2330 VAUXHALL ROAD, UNION, NEW JERSEY

VICKERS®
MAGNECLUTCH™



The most versatile and dependable clutch for power transmission and torque control . . . MAGNECLUTCHES lick the toughest application problems

The Vickers MAGNECLUTCH consists fundamentally of two rotating concentric cylinders coupled by dry magnetic particles under the influence of a magnetic field. With no direct contact between clutching surfaces, there is no wear; life of the MAGNECLUTCH is exceedingly long. Torque is easily regulated by varying the magnetizing coil current.

Unlike all other industrial clutches, torque transmitted is independent of speed. Since starting and running torques are the same, there is no grab or chatter during acceleration or braking periods; operation is extremely smooth. Torque is transmitted at zero slip with 100% mechanical efficiency. MAGNECLUTCHES have a broad range of operating speeds, provide torque limiting, fast response, and can be easily and remotely controlled.

The many unique features of MAGNECLUTCHES make them the most versatile and dependable clutches available, whether for tension control, cycling (start-stop) operation, torque limiting, controlled acceleration, wind-up, starting of high inertial loads, or constant torque transmission. ***Write for Bulletin 6000A***

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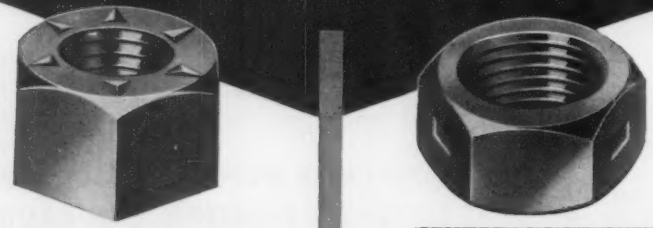
VICKERS INCORPORATED EPA 6100-1
DIVISION OF SPERRY RAND CORPORATION
ELECTRIC PRODUCTS DIVISION
1881 LOCUST STREET • SAINT LOUIS 3, MISSOURI

Circle 477 on Page 19

2 GRIPCO LOCK NUTS

at low cost that can save you production time, speed application, and resist vibration



GRIPCO LOCK NUTS

Simple, one piece design, no inserts, no separate locking devices, nothing complicated. The locking action is within the nut itself and you get low initial cost with lower application costs, WITH increased customer satisfaction. Ask for your samples now.

CENTER LOCK NUT

Can be applied from either end, double chamfered, with locking feature in the center. Greater application speeds now possible. Automatically fed, they will lock wherever turned on bolt. Available in steel from stock. Other metals on special order. Send for samples. Complete data on sizes. Write for this new FREE catalog today.

ALL GRIPCO FASTENERS AVAILABLE FOR IMMEDIATE DELIVERY

GRIP NUT COMPANY
103 Maple Ave. • South Whitley, Ind.

Circle 478 on Page 19

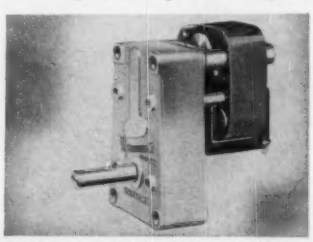
over surface, and minimum of 1500 v ac dielectric test. Contacts have 10-amp current-carrying capacity. Stock contact arrangements are DPDT on octal plugs and DPDT plus two normally open contacts on 12-pin octal style plugs. Typical unit is 1-7/16 in. wide x 2⅝ in. deep x 2-7/16 in. high, not including octal plug. **Struthers-Dunn Inc.**, Lambs Road, Pitman, N. J. E

Circle 612 on Page 19

Gearmotor

has speed range of 1 to 420 rpm

New gearmotor, with applications in units such as automatic vending machines, is totally enclosed and lubricated for life. Speed range is 1 to 420 rpm, and power range is to



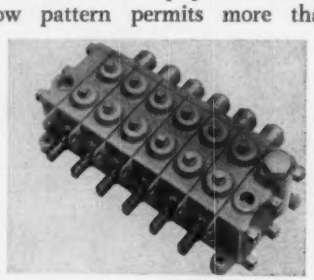
40 lb-in. Power range is available with five interchangeable motor heads plus wound shading pole reversible. Motor is equipped with rigid support for both driving and driven members. **Motoresearch Co.**, 1600 Junction Ave., Racine, Wis. K

Circle 613 on Page 19

Directional-Control Valves

are multiple-section series-type units

S4 and S6 multiple-section, series-type directional-control valves, rated for pressures up to 2000 psi, provide directional control of pump flow to and from actuating cylinders and hydraulic motors in systems for mobile equipment. Series flow pattern permits more than



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LUBRIKIT . . . An assortment of 95 oil cups of 29 different types. Gits sales records show these oilers are most used for replacement and maintenance. Contents of each separate bin are clearly described on Inside Cover.

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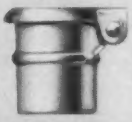
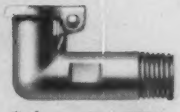
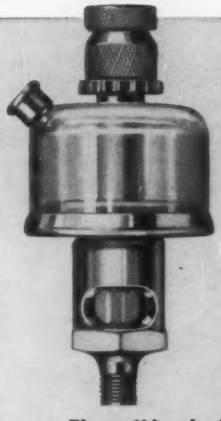


Style G — No. 505
Beaded Drive

Style GB — No. 527
Ball Valve



Style L — No. 1204
Brass Elbow (Threaded)



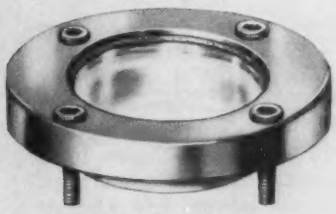
SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

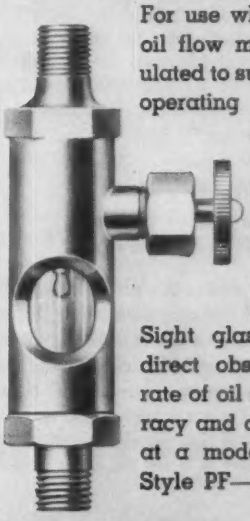
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

GEAR CASE GAUGES



Screw mounted, to set flush. Glass port is backed with white enameled reflector, to make oil level (in gear case or transmission) readily visible, even in dim light. Style CW — No. 4032.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

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Circle 479 on Page 19

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Use Vulcan Electric Tubular Heaters when you need considerable heat in confined space: straight or formed in variety of shapes for liquid, gas or metal heating; for casting into iron or aluminum. Threaded fittings are available for liquid immersion heating — water, oil, etc.

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CITY & STATE.....

Circle 480 on Page 19

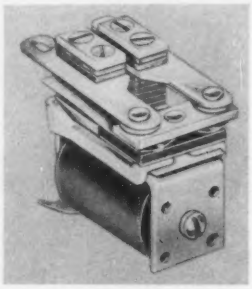
one cylinder or hydraulic motor to be operated simultaneously in a positive sequence, regardless of load equality. Increased rigidity in body design permits higher operating pressures to be used without spool bind. S4 and S6 valves are rated for 25 and 35 gpm maximum flow, respectively, and are supplied with any number of operating sections from one to ten. **Hydraulic Div., Sundstrand Machine Tool Co.,** Rockford, Ill. K

Circle 614 on Page 19

Miniature Contactor

switches loads up to 60 amp

MB miniature contactor is capable of switching loads up to 60 amp with control signals as small as 2.7 w. It is furnished with SPST double-break contacts, either normally open or normally closed. In



addition to normal load currents of 60 amp at 30 v dc, contacts handle starting surges up to 150 amp for 300 millisec. Contactor can be furnished to operate under shocks of 30-g and 10-g vibrations to 500 cycles. Tests from 10 to 55 cycles at 0.065-in. displacements fail to open contacts. Contactor is available in either open or hermetically sealed types. **Potter & Brumfield Inc., Princeton, Ind.** J

Circle 615 on Page 19

Diaphragm Fabric

is heat-resistant for use in regulators and controls

Reevecote heat-resistant diaphragm fabric is of nylon coated with Buna-N. It is particularly useful where controls operate in elevated temperatures for any length of time. Fabric has a good resistance to oils, solvents, and gas condensates. It is

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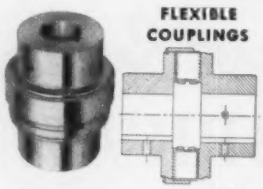

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Bores (max.).....⅝" to 9½"
O.D. .....⅜" to 21½"
Wt. .....½ oz. to 1500 lb.
H.P. .....1/20 to 4250
Torque (static).1½ to 5100 ft.-lbs.

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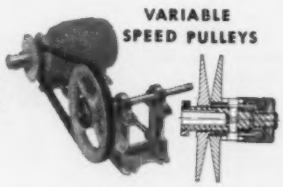

Bores (max.).....½" to 1⅜"
O.D. .....3" to 13⅜"
Belt Sizes.....A to 2¾ TW
Speed Ratios.....1-1 to 8-1
H.P. (1750 rpm.).....¼ to 15

UNIVERSAL JOINTS

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Bores.....¼" to 2"
Hub Dia. .....½" to 4"
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H.P. (100 rpm.).....½ to 207

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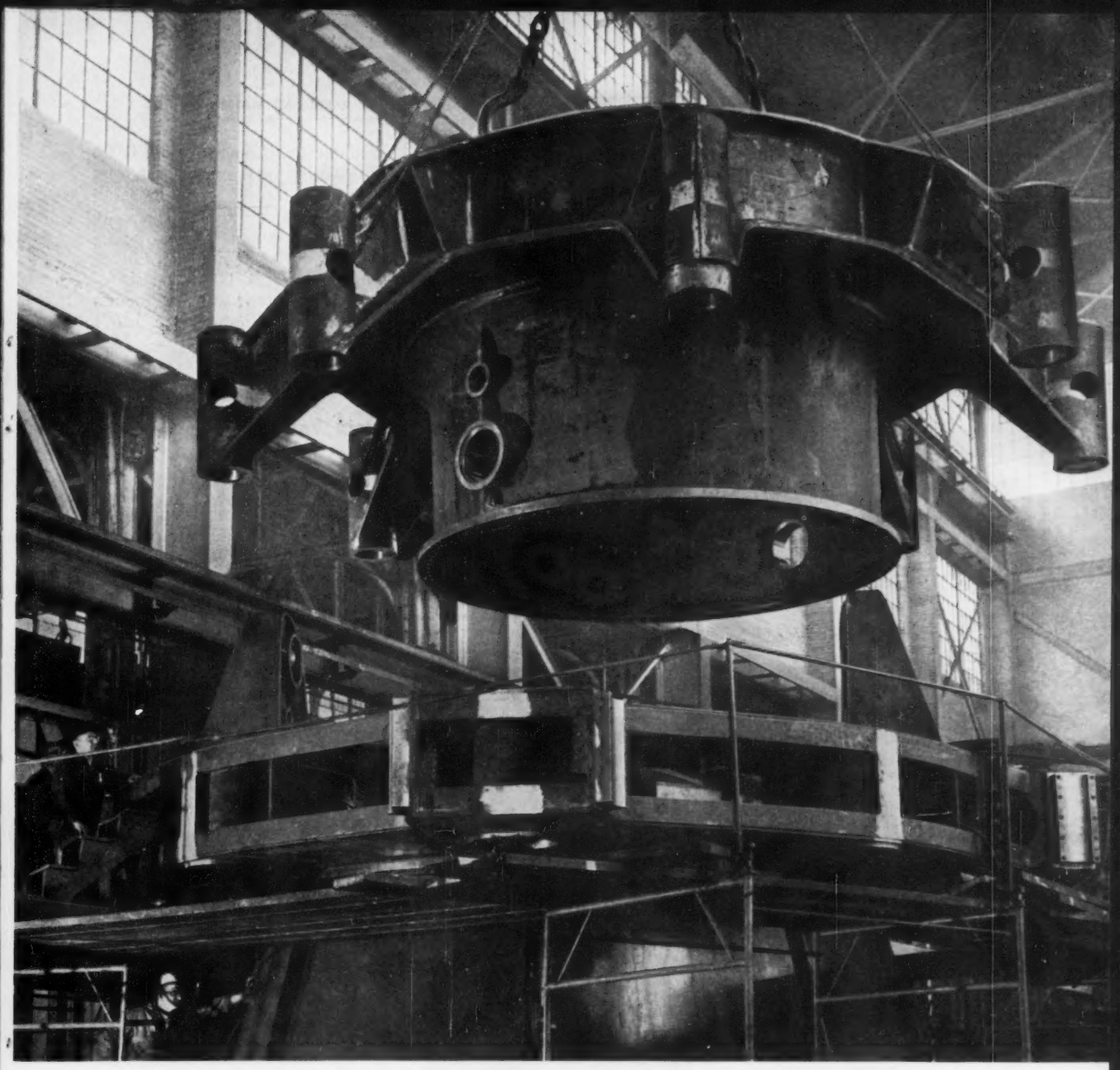
Circle 481 on Page 19



It simulates a ship in a storm-tossed sea

The machine which you see being put together here in Bethlehem's machine shops might properly be called the Great Imitator. It is a ship-motion simulator with an uncanny ability to reproduce the tossing of an ocean vessel. The simulator can rock and roll, buck and pitch, and otherwise carry on like a ship in heavy swells. It can even imitate a vessel pummeled by a hurricane.

Designed and built for the U. S. Navy by Loewy-Hydropress, a division of Baldwin-Lima-Hamilton, the 285,000-lb unit was conceived as a research tool for use at Cape Canaveral, Fla. There it should provide the Navy with valuable data in connection with the launching of missiles at sea.

That huge assembly, being lowered so carefully in the photograph above, is a Bethlehem weldment consisting largely of castings. The task of machining and assembling the many intricate parts was a major undertaking, but Bethlehem facilities were equal to the job.

Call us when we can be of service in the planning and building of specialized machinery. Our shop facilities are unexcelled, and our many years of experience with this type of work can be helpful to you.

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BETHLEHEM STEEL

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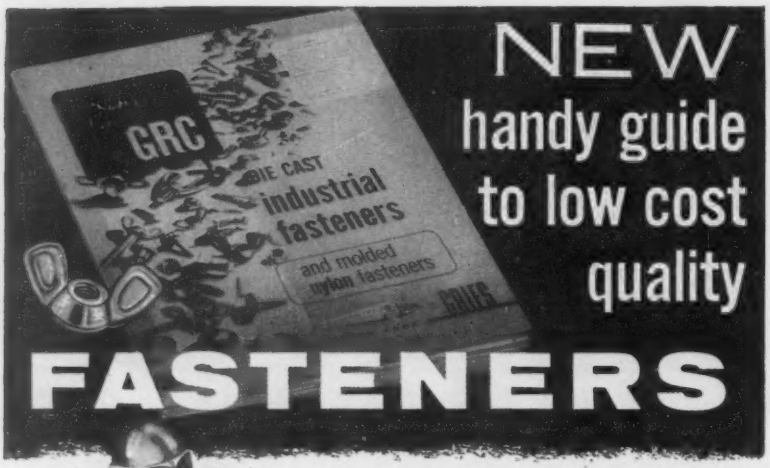
Circle 482 on Page 19



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Circle 483 on Page 19

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Circle 484 on Page 19

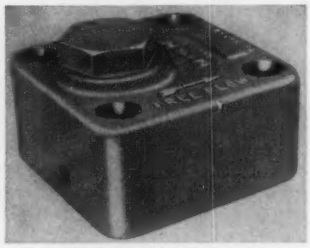
available in thicknesses from 0.006 to 0.050 in., in several widths from 36 in. up. Tensile strengths (grab method) range from 32/25 to 360/290, depending on gage of base fabric. Burst strengths (Mullen) range from 90 to 650 lb on standard styles. **Vulcan Rubber Products Div., Reeves Brothers Inc.**, 1071 Avenue of the Americas, New York 18, N. Y. D

Circle 616 on Page 19

Check Valves

for hydraulic systems to 5000 psi

New subplate-mounted and sandwich-type (shown) check valves are available for operation in hydraulic systems up to 5000 psi. Both types are available in either ¾ or 1¼-in. sizes. Subplate-type valves meet JIC standards, and are available with or without matching subplate. Sand-



wich-type valve can be added to a hydraulic circuit without adding or breaking pipe connections. It is designed to fit between any subplate-mounted sequence valve and subplate itself. The ¾-in. valves permit a volume capacity of 20 gpm, and 1¼-in. units, 65 gpm. Spring loading allows valve to be mounted in any position. **Denison Engineering Div., American Brake Shoe Co.**, 1160 Dublin Rd., Columbus, Ohio. G

Circle 617 on Page 19

Frequency Changers

400-cycle units for up to 250 kw

Synchronous motor-driven frequency changers with 400-cycle three-phase output are now available as large as 250 kw. Unit illustrated consists of a 150-kva, unity-power factor, 120/208-v, three-phase, four-wire, 400-cycle alternator mechanically connected in tandem to a 250-hp, 440-v, three-phase, 60-cycle,

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- **no extra valves—all operating controls are built-in**
- **choice of valve types: low voltage, JIC, pilot-actuated, mechanically actuated**
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- **no cumbersome piping, requires only a single air connection**
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- **made in any stroke length**
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They all add up to:

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LOWER FACTORY COST TO INSTALL!

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The Bellows Co.

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION

AKRON 9, OHIO

1221-B

Circle 485 on Page 19

Giants of American instrument industry, including such firms as . . .

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- Eclipse Pioneer, Division of Bendix Aviation Corp.
- Federal Telecommunication Laboratories, Inc.
- General Electric Co.
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CHATILLON . . . the leading manufacturer of precision springs is particularly proud of the improved performance record of instruments using the noteworthy CHATILLON developed temperature-compensated alloy "Iso-Elastic". The hysteresis error of this remarkable spring is less than .05% of deflection. Drift does not exceed .02% of deflection in 5 minutes. These characteristics plus temperature compensation insure the ultimate in precision spring production.

CHATILLON makes Extension, Spiral, Torsion, Compression and Form Springs of Iso-Elastic material, as well as springs of all conventional alloys.

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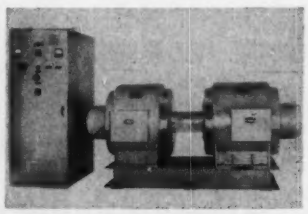


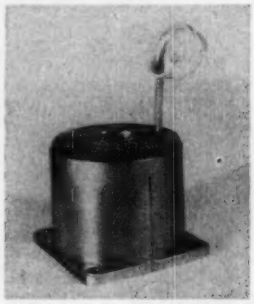
1200-rpm, synchronous-speed drive motor. Control cubicle contains all necessary metering, circuiting, and synchronous motor starter for the motor. Matching panel contains necessary automatic voltage regulator and other controls for alternator. **Kato Engineering Co.**, Mankato, Minn. J

Circle 618 on Page 19

High-Speed Solenoid

completes stroke in less than 20 millisec

RS5174 solenoid is a high-speed unit which completes its stroke in less than 20 millisec. Designed to operate with 24-lb load, unit operates



in an ambient temperature range of −65 to 160 F. Voltage rating is 24 v dc at 78 F. At this temperature coil resistance is 19.2 ohms. Unit is 1.65 in. high, with 2-in. diam case. **Telco Sales Div., Telecomputing Corp.**, 915 N. Citrus Ave., Los Angeles 38, Calif. L

Circle 619 on Page 19

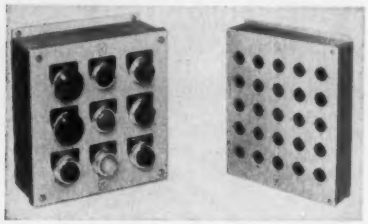
Pushbutton Enclosures

have liquidtight, dustproof construction

Line of oiltight pushbutton enclosures accommodates all standard makes of oiltight pushbuttons, switches, and pilot lights. They are available in ten sizes for up to 25 control units, and are supplied with or without knockouts or holes as required. Liquidtight, dustproof con-

Circle 486 on Page 19

struction keeps all foreign elements out of enclosures, and provides effective protection for installed electrical components. Made of 14-



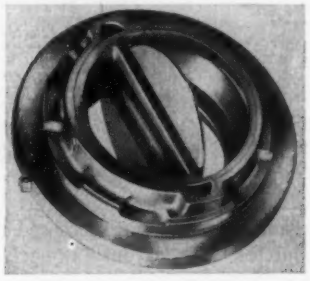
gage steel, boxes utilize welded-seam construction and are equipped with removable flanged covers with neoprene gasket cemented in position to give a positive, continuous seal. **Keystone Mfg. Co.**, 23328 Sherwood Rd., Warren, Mich. H

Circle 620 on Page 19

Check Valve

1½-in. unit withstands high-pressure air surges

New 1½-in. pneumatic check valve withstands forces caused by rapidly reversing high-temperature, high-pressure air surges. Unit, construct-



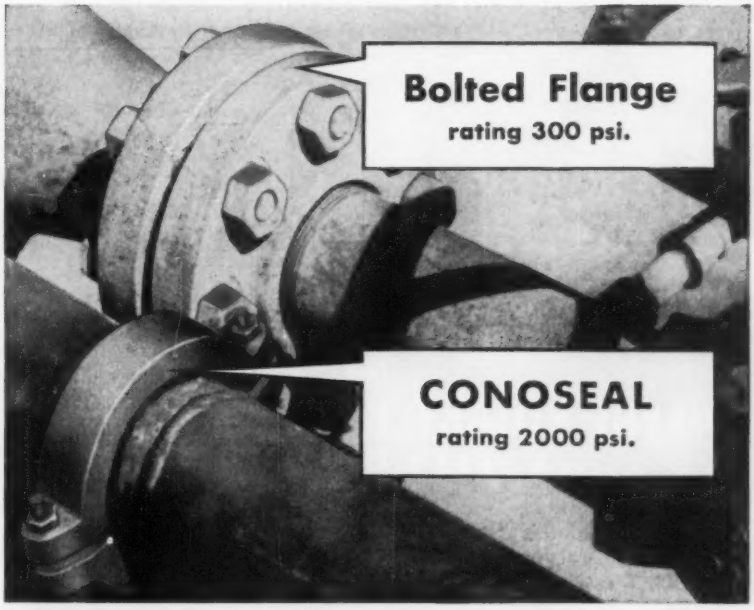
ed of 17-4PH stainless steel, weighs 0.4 lb. Maximum internal leakage is 0.05 lb per min at 150 psig and 800 F. The lightweight valve withstands 10-g vibration. **Aircraft Controls Div., Barber-Colman Co.**, Rockford, Ill. K

Circle 621 on Page 19

Wire-Wound Resistors

3, 5, and 10-w units have molded covers

Wire-wound 3, 5, and 10-w resistors have resistance wire wound in a single layer on ceramic cores. Resistor covering is a jacket of tough, resilient, silicone-ceramic material molded around resistor under great pressure, providing dense, smooth,



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Where extremes of pressure and temperature are standard operating conditions for fluid lines, specify the all-metal Marman CONOSEAL Joint. It is designed to provide absolute dependability in connecting and sealing piping, even when subject to severe shock and distortion.

Marman Heavy-Duty CONOSEAL Joints provide maximum insurance against leakage or failure where dissimilar materials must be joined, such as stainless steel to aluminum or Zercaloy. Made entirely of metals not subject to deterioration, CONOSEAL Joints have long shelf life, require no maintenance.

The Heavy-Duty CONOSEAL Joint withstands pressures up to 20,000 psi. and temperatures from —300°F. to +2000°F. It offers the rugged dependability and simplicity of installation to meet a wide range of applications. Lightweight configurations of the CONOSEAL Joint are also available. Mail coupon below for full information.

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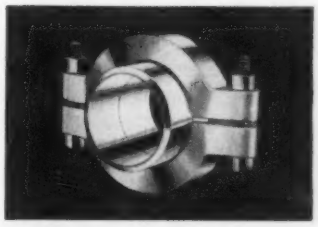

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Please send me your complete new catalog on CONOSEAL Pipe Joints. I am concerned with temperatures from _____° to _____° and pressures from _____ psi. to _____ psi.
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City _____ Zone _____ State _____

Circle 487 on Page 19

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Viscous . . . volatile . . . fast . . . slow there's a Wayne Rotary Pump to pump products more efficiently and at lower costs. Wayne Pumps are of an improved type construction—gear-within-a-gear rotary pump. The positive seal and rolling contact of the tooth design assures pump service never before obtainable . . . less down time . . . fewer replacements. Write for new catalog.

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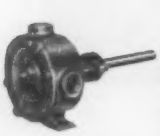
Furnished with any type of drive—gear, V-belt or direct. Complete with relief valve. Listed under re-examination service of U.L.



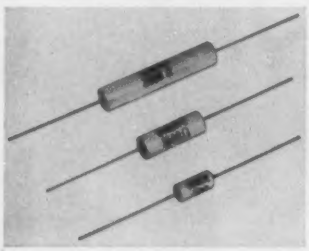
STANDARD SERVICE PUMPS

Available in capacities of 3, 5, 10, 18, 20, 25, 35, 50 and 100 gpm. Ports right or left on all models. Straight through also on 3 and 5 gpm models.

THE WAYNE PUMP COMPANY
Industrial Division
FORT WAYNE 4, Indiana
Division of Symington Wayne Corporation

Wayne PUMPS

Circle 488 on Page 19



moistureproof covering, improved heat dissipation, and reduced hot-spot temperatures. Resistors pass 1000-v V-block test and can be used next to electrically hot parts. Available tolerances are 0.1, 0.25, 0.5, 1.0, and 3.0 per cent. Maximum resistances are: 3-w, 10,000 ohms; 5-w, 25,000 ohms; 10-w, 50,000 ohms. Units meet MIL-R-26C. **Ohmite Mfg. Co.**, 3697 Howard St., Skokie, Ill. J

Circle 622 on Page 19

Plastic Gate Valves

have socket-weld ends

New socket-weld Flex-Plug plastic gate valves are available in sizes from ½ to 2 in. in PVC or styrene-copolymer. Valve offers combined

features of straight-through, no-pressure-drop flow with close throttling control, and has many applications. **Vanton Pump & Equipment Corp.**, Hillside, N. J. D

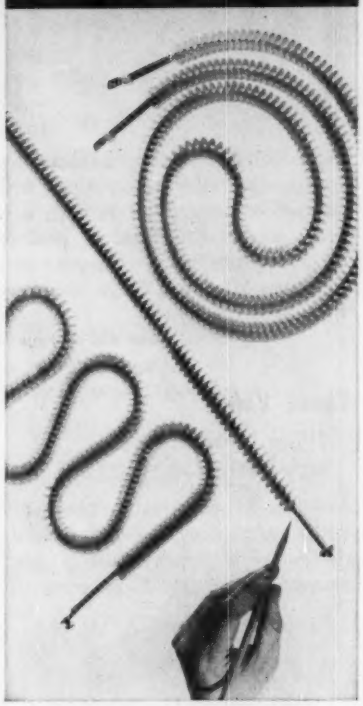
Circle 623 on Page 19

Time-Delay Relay

transistorized unit has electronic timing system

Trans-O-Netic transistorized time-delay relay employs a fully electronic timing system to achieve fast switching action, instantaneous reset, high timing accuracy, and full reproducibility of time-delay period. Transistorized control circuit operates a high-speed electromechanical

NEW Chromalox Electric Microfins for forced convection air heating



This new, small-mass heater provides rapid heat-up almost equal to open coil elements. Unlike open coils, however, Microfins offer the advantages of a totally enclosed and insulated element only ¼-inch in diameter.

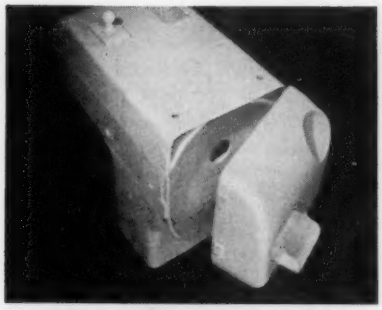
Microfins are ideal for air ducts and blower type space heaters, such as those used for industrial ovens and dryers. Their easy formability and high watt density (up to 80 watts/sq. in.) permit Microfins to pack maximum heat output into minimum space.

Standard lengths from 5½ to 47½ inches; 120 and 240 volts; 525 to 3000 watts. Specials available as required.

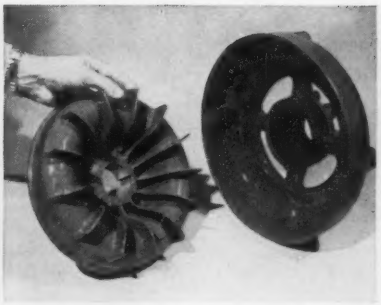
Get more information from your Chromalox Representative or write today. 2674

CHROMALOX
Electric Heat
INDUSTRIAL · COMMERCIAL · RESIDENTIAL
EDWIN L. WIEGAND COMPANY
7875 THOMAS BOULEVARD · PITTSBURGH 8, PA.

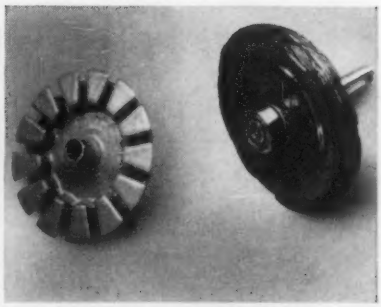
Circle 489 on Page 19



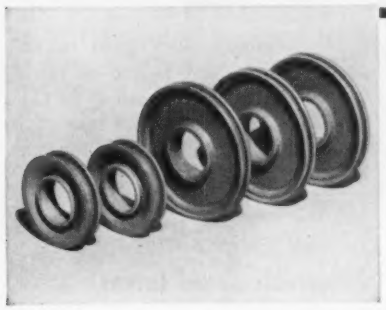
CORVEL Cellulosic Finishes—wide variety of colors with high surface gloss; excellent retention of both color and gloss in water, salt spray, sunlight.



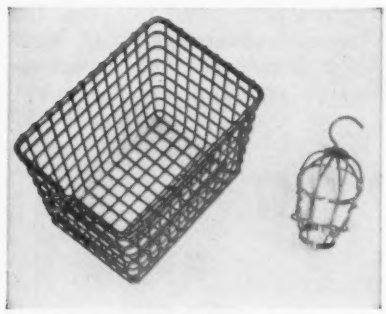
CORVEL Vinyl Finishes—durable with extreme toughness; resistant to corrosion and most chemicals. Available in a range of colors.



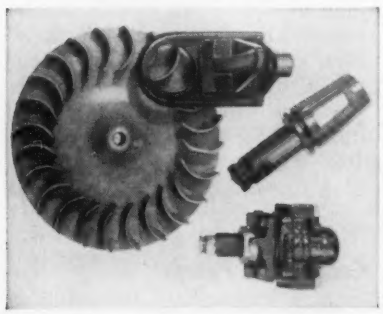
CORVEL Epoxy Finishes—excellent insulation at elevated temperatures; moisture, chemical and impact resistant. Provide a hard, smooth surface.



CORVEL Nylon Finishes—to impart the outstanding wear and low frictional qualities of nylon in coating metals and other base materials.



CORVEL Polyethylene Finishes—provide zero water absorption, excellent chemical resistance and electrical insulation.



CORVEL K-51 Penton Finishes—exceptional chemical and wear resistance. K-51 Penton finishes can withstand temperatures from —40° F. to 250 F.*

*Trademark of Hercules Powder Co.

CORVEL† Fusion Bond Finishes—

Six new engineered resins for product finishing

CORVEL finishes are specially processed dry powders, formulated for use in the patented** fluidized bed coating process. These finishes give you the following outstanding advantages:

- Comparatively heavy finishes (from approximately 0.005″ to 0.062″) obtained by a single dipping treatment—*without* the use of solvents.
- Finishes unmarred by sags, drips or bridging.
- Uniformity in thickness, with excellent coverage of sharp edges, corners and projections.

Thus, CORVEL finishes can give your products improved durability and appearance at minimum cost, and provide new design possibilities.

Process licensing is now readily available. A process license is automatically extended to the purchaser of CORVEL powders from National Polymer Products, Inc. upon payment of a small royalty added to each sales invoice. General licenses to use the patented process are available from Polymer Processes, Inc., an affiliate company.

Information relating the advantages of CORVEL Fusion Bond Finishes, to your particular products and details on the fluidized bed process and equipment are available from National Polymer Products, Inc. Write today for a copy of the new CORVEL Bulletin.

NATIONAL POLYMER PRODUCTS, INC.

A subsidiary of The Polymer Corporation

Reading, Pennsylvania

POLYPENCO

†*Polymer Corporation trademark for finishing materials*

**U. S. Patent 2,844,489 and over 30 patents pending

Circle 490 on Page 19

ROCKFORD

NEW MORLIFE® CLUTCH FACING

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

Provides Heavy-Duty Torque with S-M-O-O-T-H Engagement

Smooth engagement and disengagement is a distinguishing quality of this NEW metal-base Morlife clutch facing. It provides the extra torque required by heavy-duty highway vehicles and off-highway equipment. Unusual heat dissipation and resistance to wear insure longer life—with less frequent adjustments and replacements. It will pay you to give *your* products these competitive advantages of ROCKFORD Morlife Clutches.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

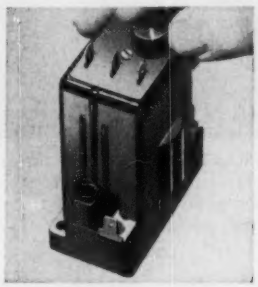
311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES

switching unit. Unit is accurate to within ± 10 per cent of specified time delay, and is unaffected by temperatures from 0 to 130 F. Re-



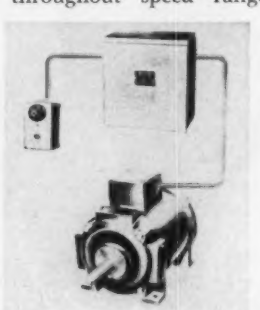
lay is available with fixed or adjustable time-delay period of 1.5 to 30 sec. Switching action is SPDT. Unit is now available for operation on 12 v dc. Weight of relay is only 8 oz. **Heinemann Electric Co.**, 709 Plum St., Trenton 2, N. J. E

Circle 624 on Page 19

Adjustable-Speed Drives

high-accuracy units have enclosed, fan-cooled motor

New adjustable-speed drives, designated Precision, are available in various horsepowers to ¾ hp, and feature regulation of ½ of 1 per cent throughout speed range as



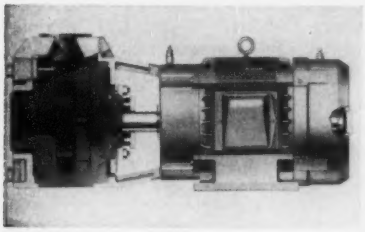
high as 100:1. All models can be operated continuously at full torque even at lowest speeds. Totally enclosed, fan-cooled motors provide protection from environmental conditions. **Servo-Tek Products Co.**, 1086 Goffle Rd., Hawthorne, N. J. D

Circle 625 on Page 19

Centrifugal Pumps

motor-mounted units resist corrosion

Three new sizes of corrosion-resistant centrifugal pumps have been added to a line of impervious-



graphite, motor-mounted Type F pumps. Designated models 22-FAL, 28-FAL, and 31-FAL, pumps are equipped with 1, 1½, and 2-hp, 1750-rpm motors respectively. At this speed, latter two types deliver up to 150 gpm as compared with 80 gpm for previous Type F units. Maximum total head for each of the new types is 33, 51, and 67 ft respectively. Corrosion-resistance makes units suitable for a wide range of applications. **National Carbon Co. Div., Union Carbide Corp.**, 30 E. 42nd St., New York 17, N. Y. C

Circle 626 on Page 19

Miniature Motor

is rated 1/100 hp at 11,000 rpm

Model 2PP1 miniature motor has been qualified to MIL-M-8609 specification. Rated 1/100 hp at 11,000 rpm, the 26.5-v dc motor is

1.18 in. in diam, 1.9 in. long, and weighs 3½ oz. Life is 500 hr without brush change. **Western Gear Corp.**, P. O. Box 182, Lynwood, Calif. L

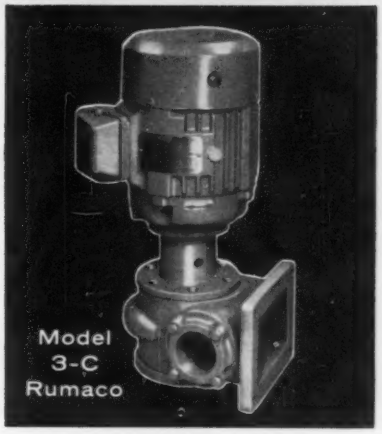
Circle 627 on Page 19

Power Package

is low-cost, self-contained unit

New low-cost, self-contained power package which produces hydraulic power from an electric source incorporates an electric motor, hydraulic gear pump with integral relief valve, check valve, and reser-

NEED A LARGER PUMP?



We can supply you with larger type centrifugal pumps for pumping coolant, some acids, oils. These pumps can—

- Pump up to 400 gallons per minute, maximum.
- Pump up to 90 foot head, maximum.

Sealess and seal type pumps, immersed or flange mounted.

They are also adaptable for high temperatures up to 600° F. equipped with fan, lantern and non-friction grease seal for fumes, etc.

or smaller pumps too...

Don't forget that Ruthman has a complete line of smaller centrifugal pumps from 1/30 horsepower. *Write for our complete catalog.*

Have you a pump problem?

As specialists in the design and manufacture of Centrifugal Pumps, we are ready to help you with any *Centrifugal* pump problems. Just call on us any time.

THE Ruthman MACHINERY CO.

- COOLANT PUMPS
- CIRCULATORS • AGITATORS
- MOLTEN METAL PUMPS

1811 Reading Road **Cincinnati, Ohio**

Circle 492 on Page 19

11 Remet

POWDERED METAL PARTS

now go into
DE WALT POWER SAW
and attachments

- This Remet collar reduced part cost 80%. Formerly a precision casting in beryllium copper, it is now a Remet copper infiltrated powdered iron part. Advantages led to DeWalt specifying 11 different powdered metal parts by Remet.
- DeWalt now offers greater saw accuracy thru maintenance of closer tolerances.
- "You can depend on Remet for better service, fast delivery," states A. C. Wedge, V.P., Mfg., DeWalt Div., American Machine & Foundry Company.

FREE, NEW BROCHURE "How to Cut Precision Parts Costs with the Remet Powdered Metal Process" gives complete information.

Send for your copy today.

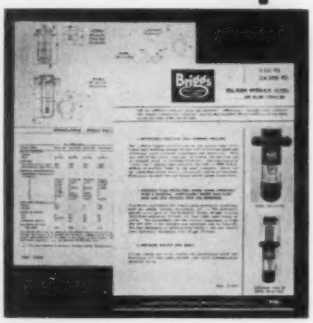
Remet

REESE METAL PRODUCTS CORPORATION
537 Howard Ave., Lancaster 11, Penna.

Gears • Pinions • Cams • Ratchets
"Oilless" Bearings • Bushings • Machine and Structural Parts in
COPPER • BRASS • IRON • ALLOY STEEL • NICKEL SILVER • COPPER INFILTRATED IRON

Circle 493 on Page 19

IF YOU ARE DESIGNING NEW HYDRAULIC EQUIPMENT WORKING FROM 0 TO 5000 PSI . . . BY ALL MEANS WRITE FOR BRIGGS' NEW BULLETIN COVERING THIS SUBJECT



This new bulletin fully describes a rugged IN-LINE, constant, high working pressure hydraulic filter than can take SHOCK AFTER SHOCK . . . day in and day out. Made especially for conditions demanding a hydraulic fluid filter "that can take it."

See how well it will fit in with your plans to prevent sticking valves and erratic machine performance. It shows how to get FULL, EASY, SMOOTH production. Packed with practical information, specifications and drawings. Use the coupon, no cost, no obligation.

Briggs

HEAVY DUTY HYDRAULIC OIL AND FLUID FILTERS

with interchangeable cartridges for mineral oils or non-inflammable fluids . . for by-pass, in-line, or high flow installations.

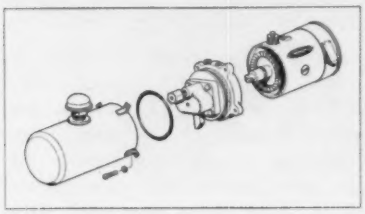
PRODUCT OF BOWSER RESEARCH

THE BRIGGS FILTRATION COMPANY, DEPT. 278, WASHINGTON 16, D. C.

SEND BULLETIN without obligation describing your heavy duty, in-line, high pressure hydraulic fluid filter.

Name .....
Company .....
Address .....

voir. Pressure-loaded bearings automatically compensate for wear to assure high volumetric efficiency and long life. Unit handles a wide variety of work loads. Capacity of gear pump is from 0.36 to 0.80 gpm. Reservoir capacities range



from 0.43 to 1 gal. Reservoir, which also serves as pump housing, is made of a single piece of deep-drawn steel for increased strength and reduced weight. Motors are open-ventilated, totally enclosed, or standard starter type. They are available for operation from a 6, 12, or 24-v dc source. **Wooster Div., Borg-Warner Corp.**, Wooster, Ohio. G

Circle 628 on Page 19

Spray-On Teflon

for use on
heat-sensitive materials

Emralon is a lubricating, corrosion-resistant Teflon film, only 0.6 mil thick, which can be applied to wood, rubber, plastics, light metal, and other heat-sensitive materials. Emralon 310 is a dispersion of TFE in a phenolic binder which can be cured in 1 hr at 300 F. Type 320 is an air-drying version for substrates that will not tolerate moderate temperature elevation, or for use where infrared or oven curing is impractical. Coating, which withstands temperatures from −450 to over 500 F, is also applied to avoid dirt, grease, and corrosion on base material. **Acheson Colloids Co.**, P. O. Box 288, Port Huron, Mich. H

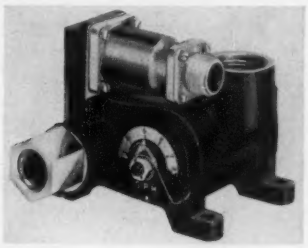
Circle 629 on Page 19

Constant-Flow Regulator

is adjustable from
3 to 8 gpm

New constant-flow regulator operates at temperatures from −65 to 250 F. It maintains constant flow rate regardless of pressure differentials of 30 to 100 psi, and preset

Circle 494 on Page 19



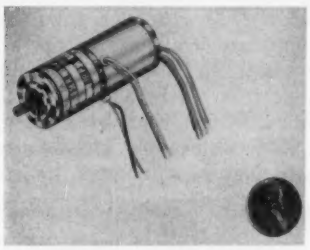
flow rate is adjustable from 3 to 8 gpm. Unit incorporates a filter, normally open solenoid shut-off valve, pressure-relief valve, and reverse-flow check valve. It can be modified for pressure differentials up to 3000 psi. Designed mainly for injected water-alcohol applications, unit also controls flow of other liquids such as fuels, hydraulic, and lubricating oils. Inlet line size is ¾ in., outlet line size, ½ in. Unit weight is 1.9 lb. **Aero Supply Mfg. Co. Inc.**, Corry, Pa. F

Circle 630 on Page 19

Motor-Generator

size 8 unit has OD of 0.750 in.

Size 8 motor-generator has an OD of 0.750 in. Tachometer-generator section operates on either 18 or 26 v, 400 cycles. It has a gradient of 0.250 v per 1000 rpm and maxi-



mum null voltage of 0.010 v rms. Motor portion is furnished with any combination of voltages up to 40 v on both fixed and control phases, all 400 cycle. Stall torque is 0.3 oz-in., with no-load speed of 6200 rpm. **G-M Laboratories Inc.**, 4300 N. Knox Ave., Chicago 41, Ill. I

Circle 631 on Page 19

Adjustable-Speed Drive

provides three speeds from 0 to 3600 rpm

Servotran adjustable-speed drive with solenoid-operated speed control provides any three speeds, for-

HIGHEST COMPRESSIVE STRENGTH *of all* DRY BEARINGS

GLACIER

DU

THE SENSATIONAL BREAK-THROUGH IN DRY BEARING TECHNOLOGY

DU—a steel-backed porous bronze bearing material, impregnated with a permanent, solid, T.F.E.* fluorocarbon resin-lead lubricant—withstands loads up to 23 tons per sq. in. with *no cold flow.*

In addition, its wear resistance 10 to 100 times that of other dry bearings—

Its extremely low coefficient of friction, with no slip-stick characteristics—

Its consistent performance at temperatures ranging from 328 degrees below zero to 500 above—

Its immunity to detergents, solvents, corrosive chemicals, alkalies, abrasive atmospheres—

Its ability to run submerged in liquids—usually with improved performance—

Its positive elimination of contamination from oils and greases—

All these unique characteristics make GLACIER DU the most sensational break-through in dry bearing technology.

Consider what this new bearing material can mean to your products. Ask your bearing manufacturer or write for complete brochure to—

SPECIAL PRODUCTS DEPT.
United States Gasket Company
Camden 1, New Jersey

*TEFLON, *du Pont Trademark*
FLUON, *I.C.I. Trademark*

United States Gasket *Plastics Division of* **GARLOCK**

Circle 495 on Page 19

Foundry Engineering aids product development!

This steel casting is another example of Unitcast's ability to cope with unusual problems. As the main body of a new-type Pulsation Dampener for The National Supply Company's oil field equipment, this casting had many tough end-use requirements. Basically, the part had to absorb shock, withstand corrosion, and hold hydrostatic test pressures up to 8,000 psi. The fewer the components in the part, the better the durability.

The ideal solution, a one-piece steel casting, required accurate suspension of a huge core on a minimum number of points to produce a horizontal "tank" within consistent tolerances. One subsequent finishing problem involved economically "sealing" the core suspension holes by a method that would hold up in end use—*plus* pass radiographic inspection!

Once again, Unitcast foundry engineering has helped a customer develop a new product for their well-known line. Why not call in Unitcast engineers on your product-development problems? Write today!

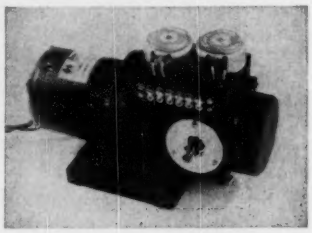
UNITCAST CORPORATION, Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

ward or backward, from 0 to 3600 rpm. Shifting from one speed to another is accomplished in less than 1/10 sec without disengaging drive or load. Selector switch for changing speeds can be placed anywhere wires will reach. Standard unit now



available has two solenoids mounted on top of unit to give three output speeds and off. Drive is available with two standard motor sizes covering ranges from 1/70 to ¼ hp. Repeatability and accuracy of speed setting is within ½ per cent. Output torque is constant, and efficiency is between 85 and 95 per cent. **Humphrey Products Div., Humphrey Inc.,** 3794 Rosecrans St., San Diego 10, Calif. L

Circle 632 on Page 19

Fluid-Power Pumps

for operating pressures to 2000 psi

Series 2100 gear-type fluid-power pumps are available for operating pressures to 2000 psi. Ratings range from 16 to 32 gpm at 1800 rpm, 2000 psi, and up to 40 gpm at 1500 psi. Features include a two-stage high-pressure seal that runs

cooler, improved shaft bearings, thrust bearing to take axial thrust of hydraulic forces, and piloted housing design to eliminate shifting of internal parts. Various standard flange mountings are provided for mobile applications, and foot mounting for industrial applications. **Hydreco Div., New York Air Brake Co.,** Kalamazoo, Mich. H

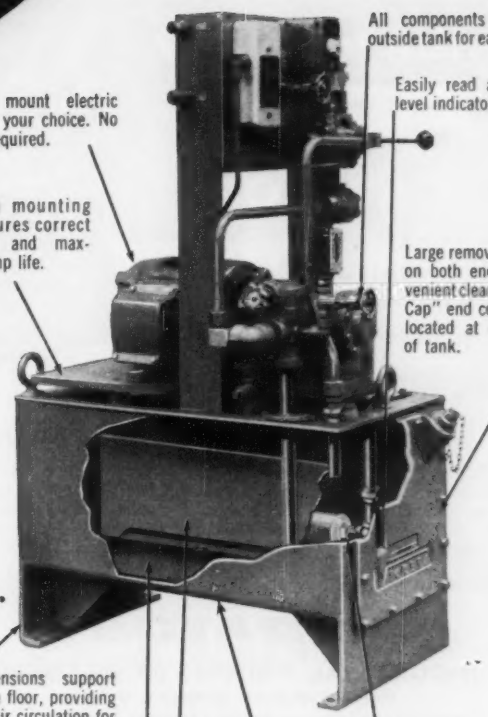
Circle 633 on Page 19

Circle 496 on Page 19

Circle 497 on Page 19→

You save money and time applying Hydraulics when you buy the . . .

VICKERS *package . . . . . instead of parts*

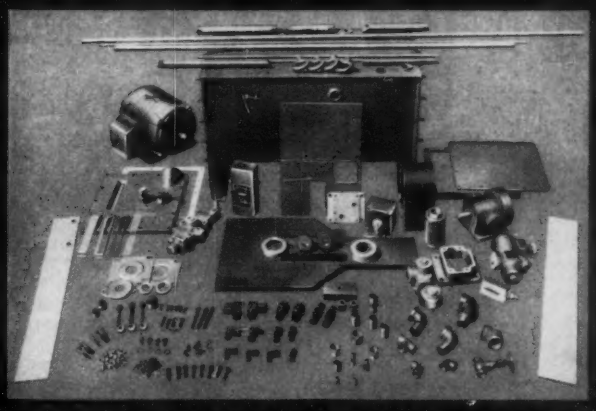

All components mounted outside tank for easy access.
Easily read accurate fluid level indicator.
Standard mount electric motors of your choice. No specials required.
Separate mounting plate insures correct alignment and maximum pump life.
Large removable covers on both ends for convenient cleaning. "Filler Cap" end cover can be located at either end of tank.
Side extensions support tank above floor, providing complete air circulation for maximum heat rejection.
Corrosion protection—internal tank surfaces sand-blasted and specially painted.
Inlet strainers can be removed and cleaned without disconnecting components or pressure piping.
New baffle plate improves fluid circulation.
Easy accessibility to drain plug.

Vickers Custom Built Power Package . . . complete . . . factory pretested . . . ready to connect and operate.

You save time and expense of design, layout, multiple purchasing, and assembly when you buy the Vickers package. You are assured of component compatibility and Vickers undivided responsibility and guarantee for the entire hydraulic package.

A Vickers Custom Built Hydraulic Power Package is a "complete unit" . . . factory pretested, ready for you to connect and operate. Designed and professionally built to your specifications.

Call in a Vickers Application Engineer or write for Bulletin 5001B.



These parts are required to build the Power Package shown above. Purchasing the complete package from Vickers saves you the time and cost of design, assembly, and testing. It also assures the most suitable unit for your particular requirements.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
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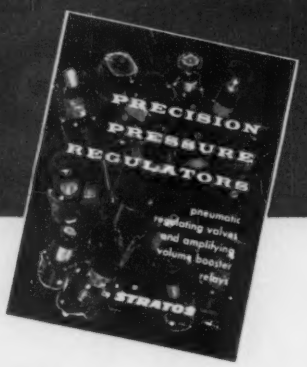

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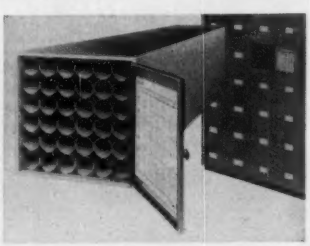

through unnecessary handling, and protects drawings when stored. File has index record of contents on inside of door and label holder on outside. Units can be placed horizontally or stood on end. Four file-tube lengths range from 30 to 60 in. **Stacor Equipment Co.**, 295 Emmet St., Newark 5, N. J. D

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Microfilm Mounting Device

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With new Snap-Jack, it is possible to remove a specific filmed document from a roll of film, insert it quickly into a pocket, and in turn snap into any type of filing card with a precut aperture. It is designed for any situation where document itself must be an integral part of a card which contains additional information. Snap-Jack is a transparent tri-acetate holder into which film is inserted, accommodating an image of 16, 35, or 70-mm film. Top and bottom edges consist of two facing pieces of tri-acetate. These are snapped into place on top and bottom edges of aperture in card. Remaining area of card provides space for data. **Remington Rand Div., Sperry Rand Corp.**, 315 Fourth Ave., New York 10, N. Y. D

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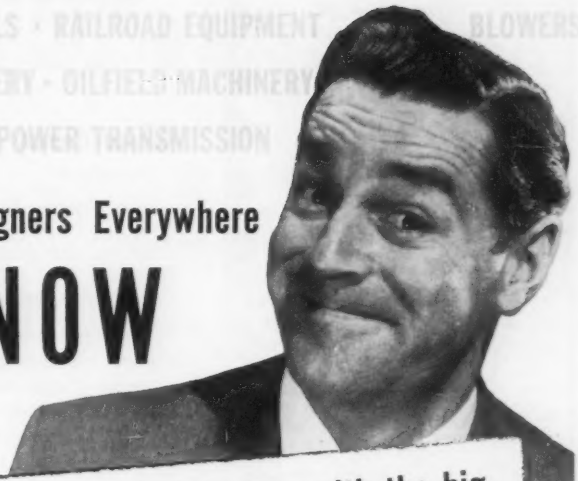

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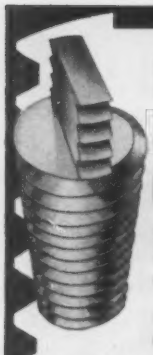

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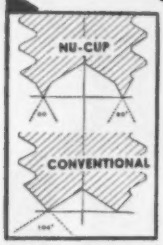

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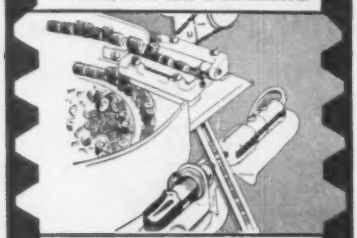

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Circle 501 on Page 19

THE ENGINEER'S Library

Recent Books

Gum Plastics. *By M. S. Thompson; 193 pages, 5 by 7½ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; $4.50 per copy.*

Emphasis throughout this book is placed on the general properties, chemistry, and fabrication of gum plastics. Included are discussions on the advantages of gum plastics in terms of product improvement, and how certain disadvantages of these materials can be overcome.

New Standards

American Standards. *Each publication is 8 by 10½ in., paperbound and side stapled. Copies are available from American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.*

The following standards are available:

American Standard Brass Fittings for Flared Copper Tubes, ASA B16.26-1958; 8 *pages;* $1.50 *per copy.*

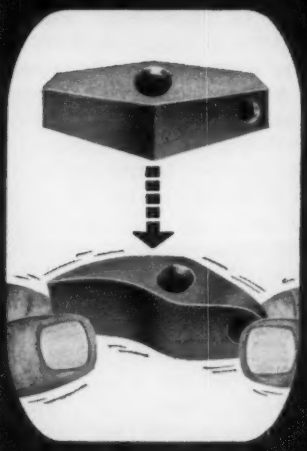
American Standard Letter Symbols for Petroleum Reservoir Engineering and Electric Logging, ASA Y10.15-1958; 14 *pages;* 1.50 *per copy.*

Association Publications

The Metal Thorium. *Edited by Harley A. Wilhelm; 394 pages, 6 by 9 in., clothbound; published by and available from American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio;* $10.00 *per copy.*

Proceedings of the Conference on Thorium sponsored by the Atomic Energy Commission and American Society for Metals are included in this book. Among the subjects discussed in the papers are the preparation, production, and properties of thorium. The papers on the properties of thorium give information on the physical constants,

just to *stretch* a point.



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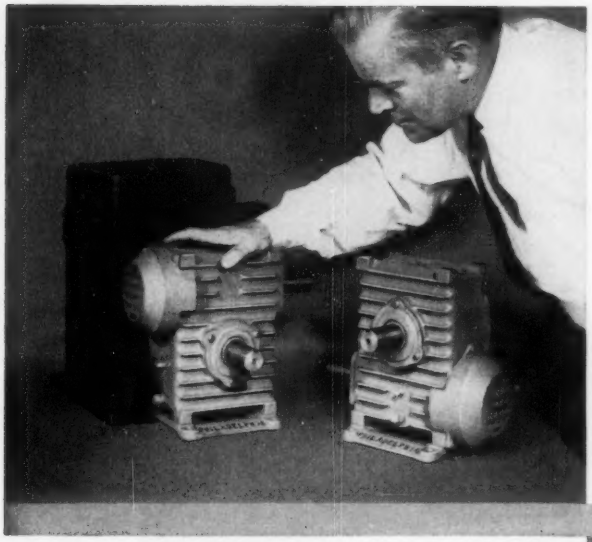

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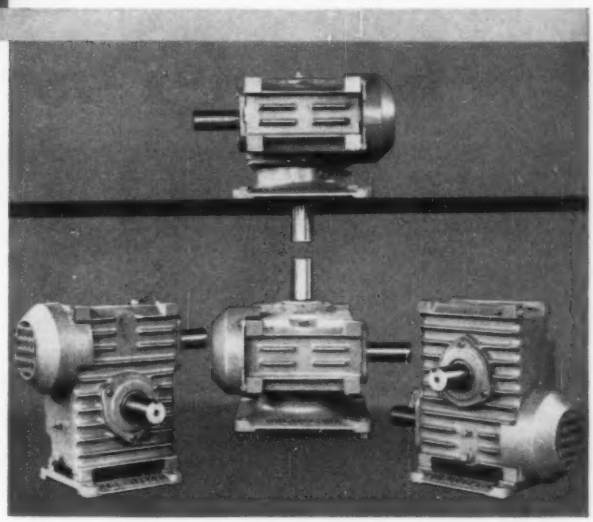

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Electrodeposited Metallic Coatings. *124 pages, 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $2.25 per copy.*

Included in this standard are specifications and tests for such materials as electrodeposited zinc, cadmium, nickel, chromium, and lead for steel. In addition, coatings for copper, copper-base alloys, zinc and zinc-base alloys are also included. This book contains seven specifications, three methods of tests, and nine recommended practices for metallic coatings.

Report on Elevated-Temperature Properties of Chromium Steel. *Prepared by Ward F. Simmons and Howard C. Cross; 113 pages, 8½ by 11 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $4.25 per copy.*

This report presents curves and data on the elevated-temperature strength properties of various chromium steels.

Government Publications

NASA Technical Series. *Each publication is 8 by 10½ in., paperbound, copies available from National Aeronautic and Space Agency 1512 H St., N. W., Washington 25, D. C.*

The following reports are available:

TN 4160. Thermal Fatigue of Ductile Materials I—Effect of Variations in the Temperature Cycle on the Thermal-Fatigue Life of S-816 and Inconel 550. *By Francis J. Clauss and James W. Freeman; 61 pages.*

TN 4165. Thermal Fatigue of Ductile Materials II—Effect of Cyclic Thermal Stressing on the Stress-Rupture Life and Ductility of S-816 and Inconel 550. *By Francis J. Clauss and James W. Freeman; 43 pages.*

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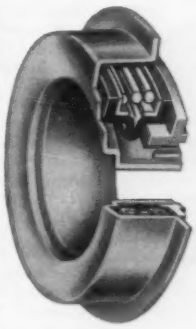

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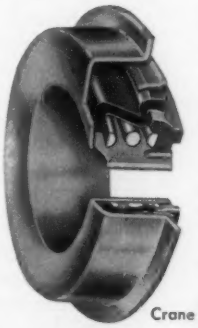

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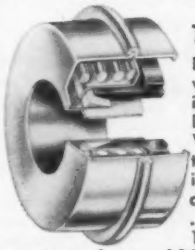

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Circle 505 on Page 19

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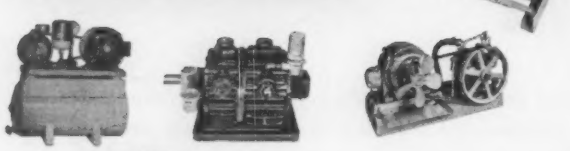

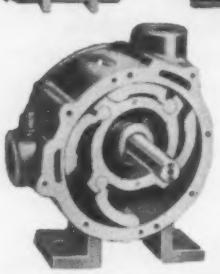

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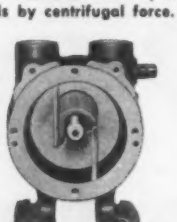

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Professional Viewpoints

. . . bargaining by press release . . .

To the Editor:

Adequate communication between the management of a company and its employees certainly depends on many factors. If all of these factors were based on simple logic, the problem of adequate communication could be solved easily. Unfortunately, the complex emotional factors associated with the problem far outweigh the so-called "logical" factors. For proof of this statement, turn to any successful magazine and survey the advertisements. The purpose of these is to communicate to the reader that the touted product warrants his attention and eventual use. The reader's attention is usually drawn to the advertisement by an emotional appeal through the use of appealing color, a design, a bathing beauty, or plain "propaganda." In some ads, unemotional facts support claims; in most, the play on emotions is the only message. Thus it is fairly safe to conclude that an emotional approach is not only logical but is the most effective means of communication.

But setting emotions aside, if one can, consider your editorial of August 21, 1958, "Bargaining by Press Release." It starts with the premise that "like it or not, unionization of engineers seems here to stay." (Use of the phrase "unionization of engineers" arouses the reader's emotions since it suggests that something is being done to the engineer against his wishes.) Added to this is the suggestion that this unionization process can be limited by a "stronger show of interest by management in the problems of the engineer," and "a more professional attitude among engineers." These statements are followed with the observation that "the existence, and relative success, of engineering unions are symptoms of a failure in communications." With these premises, you then attempt to establish that it is "unprofessional" to let the public in on negotiations.

Communication, Publicity, and Secrecy

And here is where you meet yourself coming back! Communication with professionals, or any other group in the business world, is the flow of accurate and adequate information with a minimum of obstruction from management to the employee and from the employee to management. Such a free flow of information cannot prevail in an atmosphere of secrecy. But your admonishment against "bargaining by press release" has the effect of establishing secrecy as synonymous with "professional" by implying that publicizing difference of opinion in the collective bargaining situation is to be avoided because it is not "professional." Certainly it is obvious that professionals, as well as management, must exercise discretion in matters of a personal nature or in matters pertaining to the competitive position of the company concerned. But this is where secrecy among professionals must end!

Even assuming that the publication of a difference

of opinion is one-sided, this is still a step in the communications process. The development of science in all forms thrives on differences of opinion. Why should the process of communications in professional personnel relations be different? The fact that it is the primary function of a professional to render a professional service to his employer should not stand in the way of that professional's reasonable freedom of thought or action. If, as you suggest, the engineering collective bargaining group indulges in "propaganda gambits," the professionals supporting the group should be able to judge this for themselves.

Engineers would be the first to exert democratic pressure to prevent recurrence of such "transparent strategy" if it is really objectionable. On the other hand, if the seeming propaganda gambit has the full support of the Professionals in the group, they, rightly or wrongly, have at the very worst participated in a form of communication which involves not only facts but emotion as well! This form of communication would not be used at all if it were possible for the engineering group to communicate with its management on the basis of facts alone. Moreover, one must keep in mind that the justice of the usually undesirable label of "propaganda" depends largely upon who is judging.

Causes of Public Bargaining

Engineers are the most likely group to believe in and support facts and reasons. When you see such a group resorting to "bargaining by press release" you can be reasonably sure it is the result of one or both of two factors. The first of these is the failure on the part of the professionals in the group to see that such "propaganda" has departed from "facts and reasons" because the group has become involved emotionally. The second, but by far the most significant, is the failure on the part of the members of management, who are supposed to be experts in communications with personnel, to give these same engineers any reason to believe that such "propaganda" is unreasonable and unnecessary.

Considering the emotional factors always present in human relations, one must be wary of criticizing any form of communication . . . even "bargaining by press release." Though we may be offended by a statement, it is probably better to be offended than ignorant. The fact remains that management needs professional engineers, and professional engineers must be managed. Unless and until both groups will admit this and communicate effectively, technological progress will continue at only a fraction of its potential rate.

Most significant of all is the fact that real communication between management and professionals has become a topic of intense interest and discussion after only a few engineering organizations have resorted to "bargaining by press release." Think of the real progress that can be made in the field of personnel communications as more and more engineers become organized, bargain collectively, and thereby communicate more effectively.

—JOHN A. GESHNER
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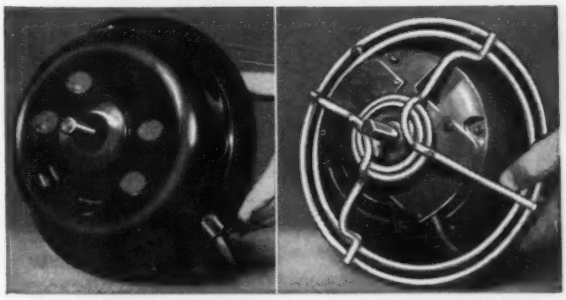

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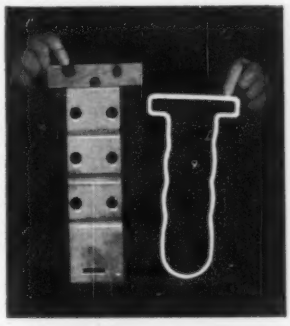

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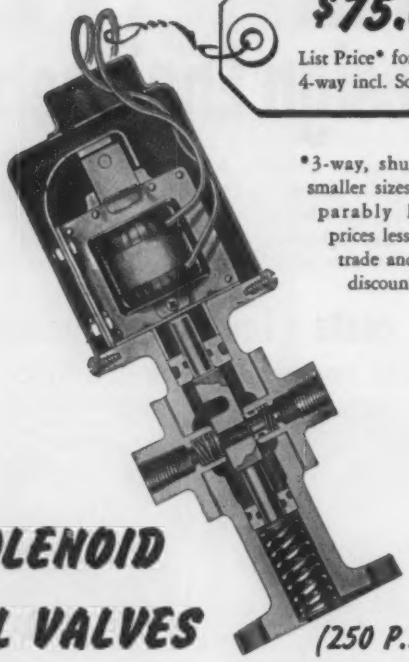
List Price* for a ½" 4-way incl. Solenoid



*3-way, shut-off and smaller sizes are comparably less. All prices less the usual trade and quantity discounts.

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Hydraulic work feed apparatus	(Leakproof) ... as versus spool valves which cause over-demand on hydraulic system	Positive shut off of internal port to port leakage and of course, no external leakage
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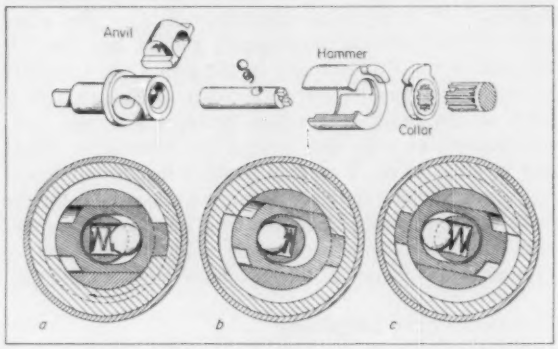
NOTEWORTHY

Patents

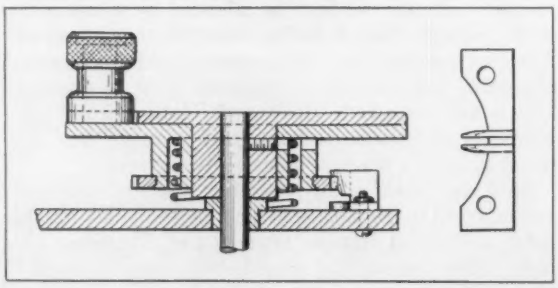
Torque-Responsive Impact Clutch

Output from a drive mechanism is continuous and uniform while torsional resistance remains below a certain value, but a sudden increase in resistance, as



occurs in driving screws, changes output to be a succession of torsional blows. A hammer member is driven continuously, regardless of resistance, by engagement with a collar splined to the power source. The same rotation is delivered to a shaft inside the hammer. A spring-loaded ball projecting radially from the shaft rolls in the slot of the anvil member. Shoulders inside the hammer engage the anvil projections, *a*. Instantaneous lessening of friction upon impact, *b*, allows the spring to move the anvil radially into position, *c*, for another blow. *Patent 2,850,128 assigned to Rotor Tool Co., Cleveland, by Paul R. Van Sittert.*

Positive-Locking Dial Mechanism



A dial mechanism is locked at settings by a ring gear and stationary prongs held in engagement by a coil spring. To change settings, a knob is depressed against the force of the spring. This motion disengages the gear teeth from the prongs. In the depressed position, the knob carries an outer disc and the main shaft to other settings where the mechanism is locked again when pressure on the knob is released. *Patent*

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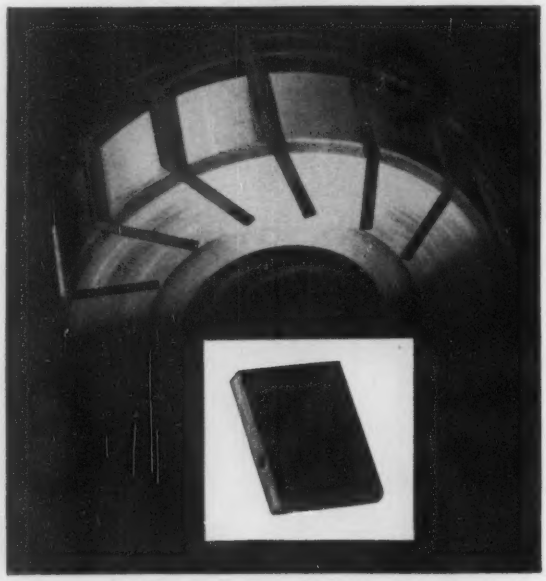
a material answer may be found in molded carbon

SUPERIOR



For example: pump vanes successfully perform when made of carbon

More and more, molded carbon graphite is filling roles heretofore played by other materials. Aside from possible cost reduction, advantages found in this non-metallic are: low noise level, self-lubrication, low coefficient of expansion, chemical inertness. Carbon has other important qualities usually associated with metals, too, such as impact and shear strength, dimensional accuracy, hardness, resistance to abrasion, and can be made non-porous.

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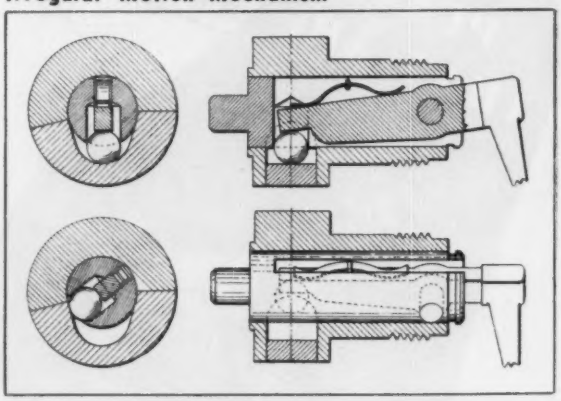
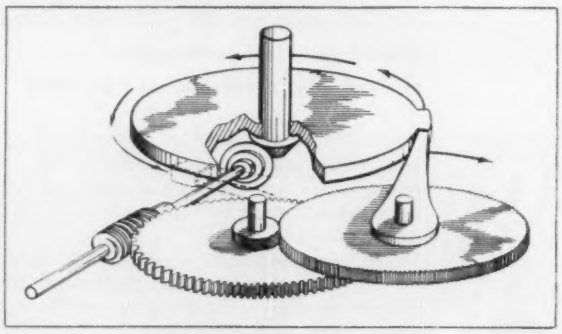
2,841,034 *assigned to the United States of America by Thomas T. Greene.*

Irregular Motion Mechanism



Rocking and oscillating motions are imposed simultaneously on the base member of an arm assembly to enable the opposite end of the arm to sweep uniformly over a given curved surface. The base member is free to pivot about a pin which holds it in a hollow oscillating shaft. As the shaft turns, a ball follows an internal cam the contour of which is roughly a function of the profile of the surface being swept. A leaf spring causes the end of the arm base member to follow the ball, thus causing rocking motion. Representative application is an automobile windshield wiper. *Patent* 2,852,799 *assigned to General Motors Corp., Detroit, by Cyril T. Wallis.*

Fine-Pitch Limit-Stop Gear Train



Gear ratios as high as 1:10,000 are possible with a mechanical limit stop system in which there is no danger of shearing teeth at either end of travel. A pawl, fixed on the last gear, engages a stop on the rim of a plate fixed to the shaft of the first gear. The gear axes are so disposed that the forces acting on the pawl at the limit positions are tangential to the stop plate and pass through the axis of the pawl gear. Since gear teeth are not used to stop the train, small teeth and, thus, large ratios are possible. *Patent* 2,844,038 *assigned to Hoffman Electronics Corp., Los Angeles 7, Calif., by Robert C. Danta.*

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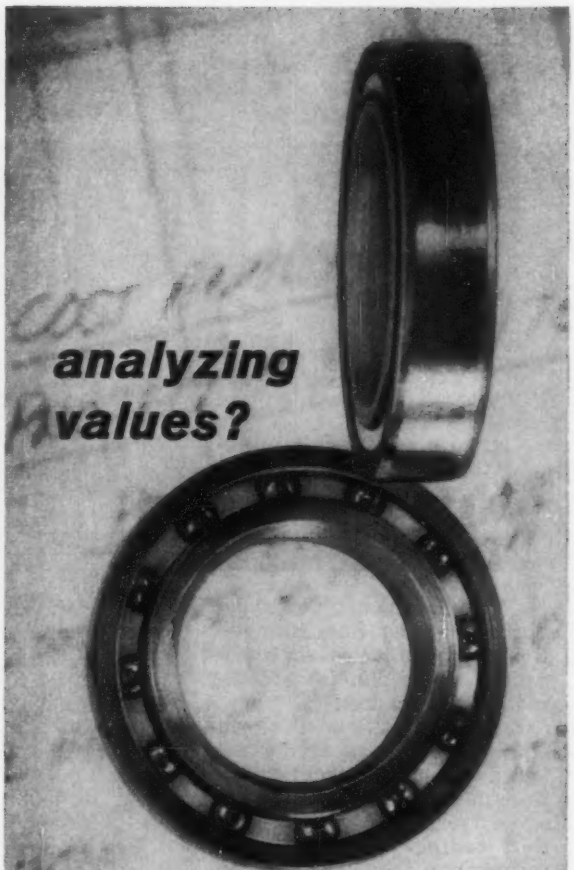

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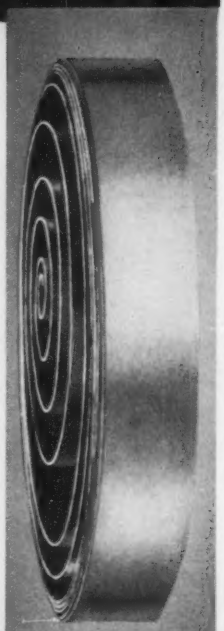

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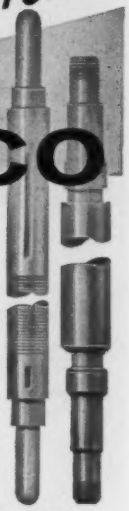

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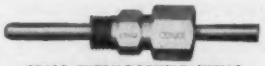

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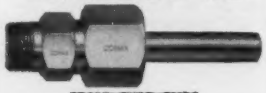

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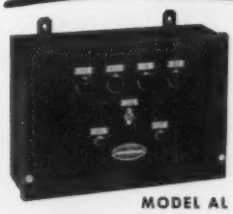

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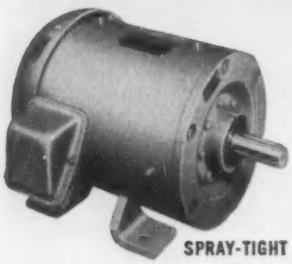

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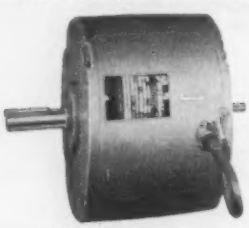

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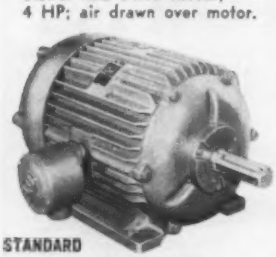

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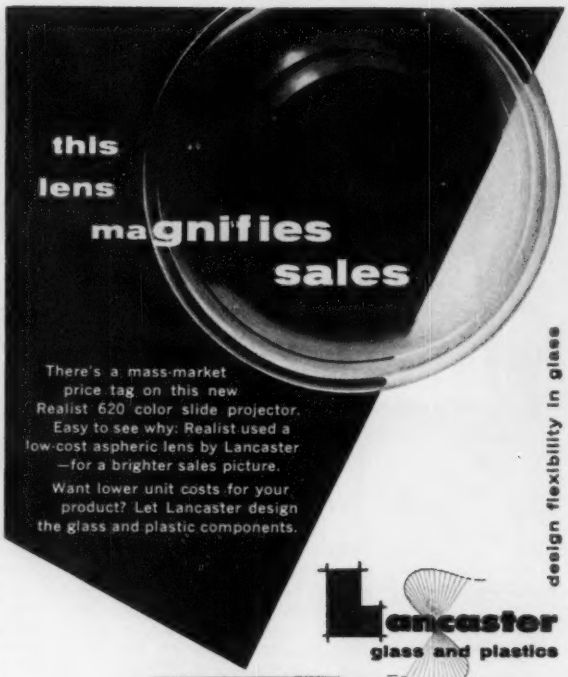
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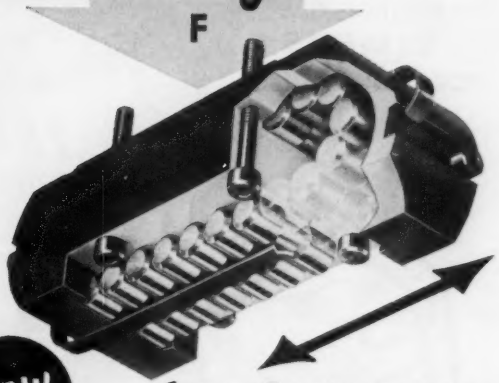

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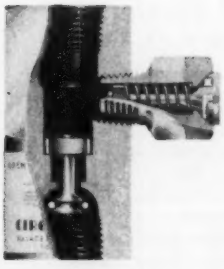

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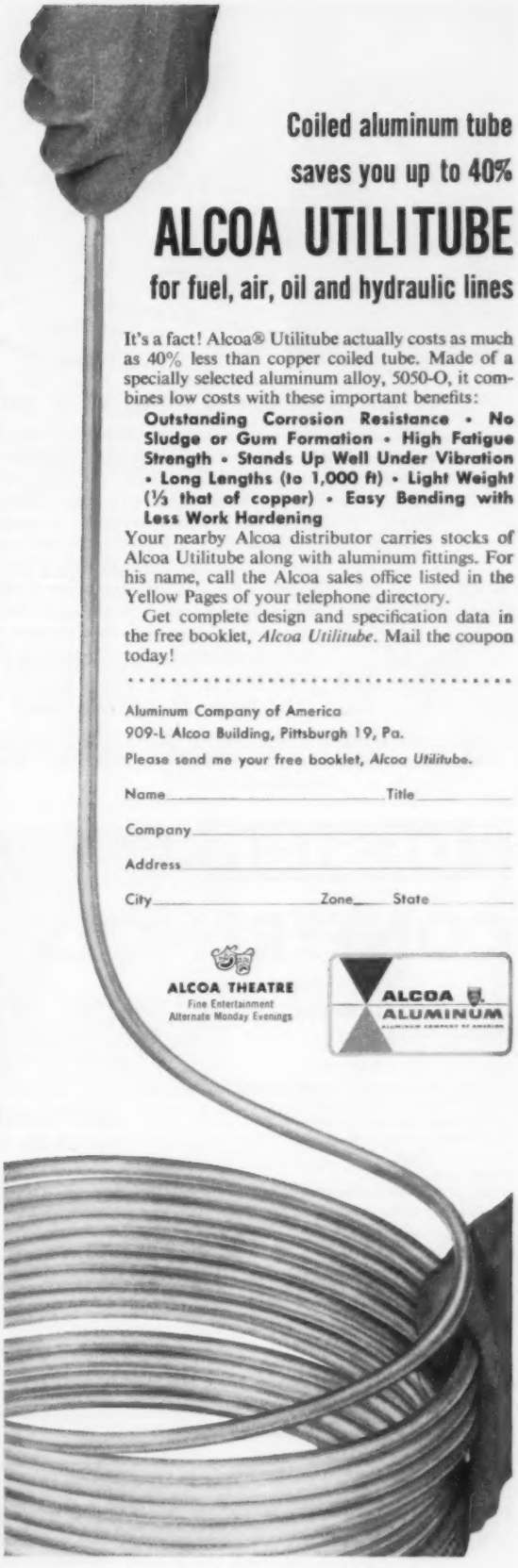

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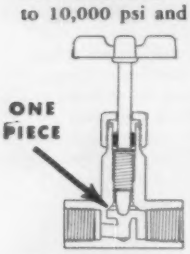

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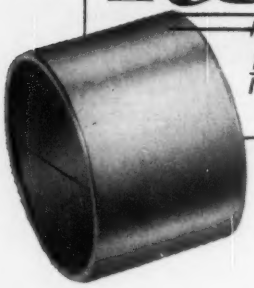

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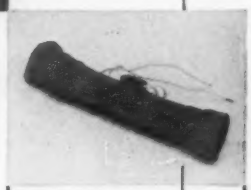

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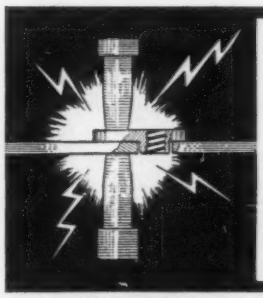

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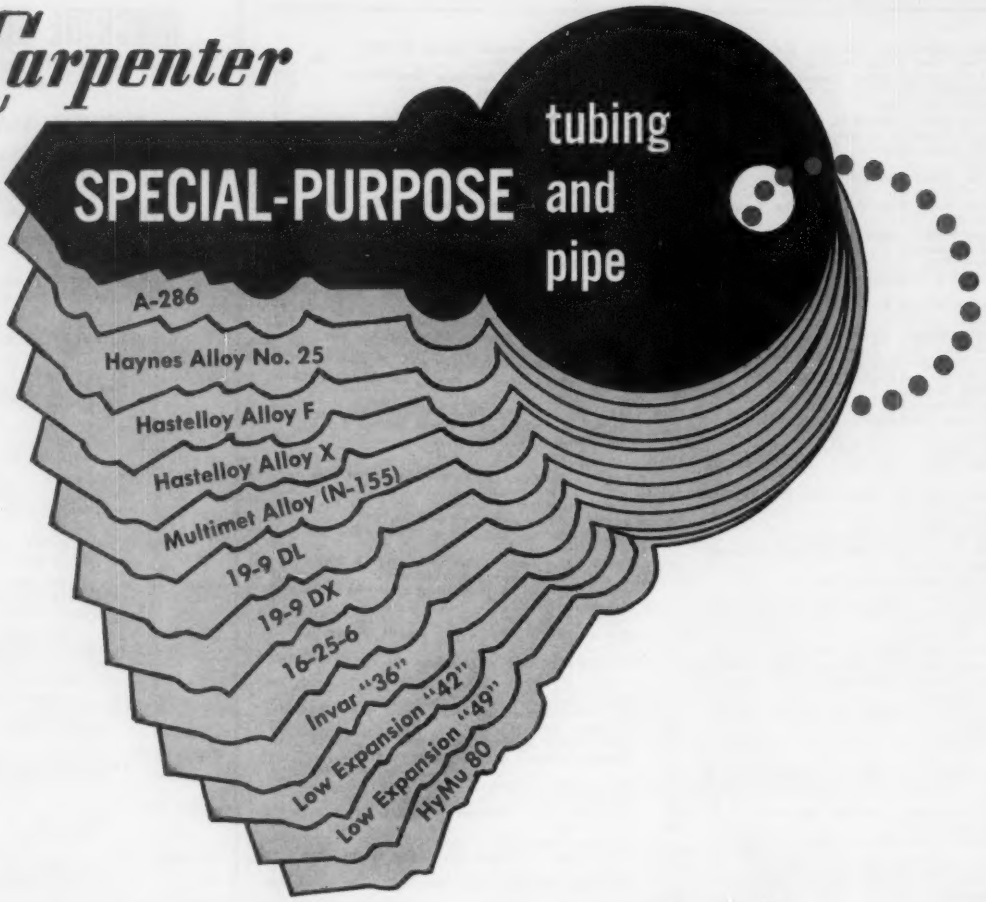

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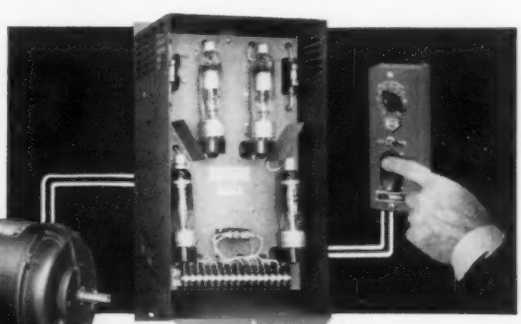

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AND ENGINEERING COMPANY
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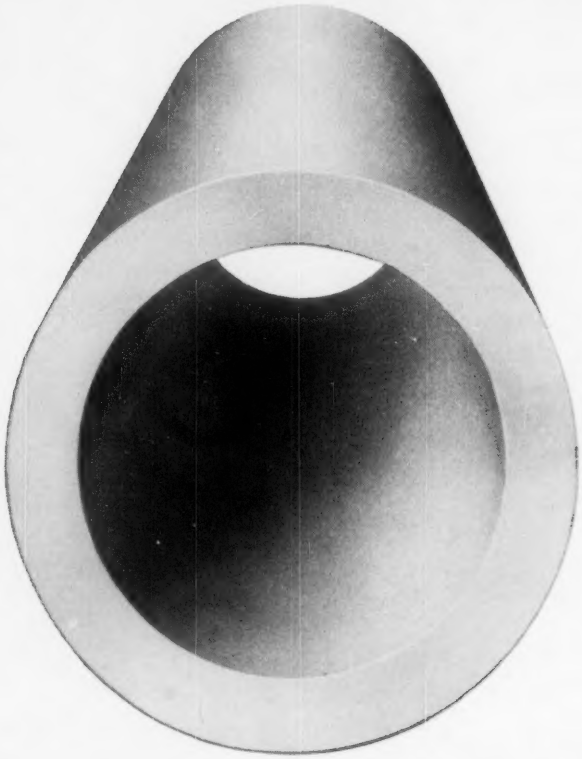
How to step up production of hollow parts



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